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THE PROGRESS OF FOREST ENTOMOLOGY IN THE UNITED STATES[1]

ABSTRACT

A biographical sketch of Dr. A. D. Hopkins, the father of forest entomology in this country, whose studies established the great economic importance of forest insects, the percentage principle of control, the host selection principle, some of the possibilities in silvicultural control and business management and the value of the Bioclimatic Law as a guide in control work. The application of these investigations is exemplified by the studies of assistants to Dr. Hopkins, W. F. Fiske on the gipsy moth, Dr. F. C. Craighead on the locust borer, and Dr. T. E. Snyder on white ants. There is great need for further investigations along these lines and for the closest cooperation between forester and forest entomologists in developing silvicultural methods and modifications in mangement.

On July 12, 1923, Dr. A. D. Hopkins who has been in charge of forest insect investigations of the Bureau since July 1902 was, in accordance with his expressed wishes, transferred from his former duties to that of special research in bioclimatics.

Dr. Hopkins enters a field extremely important and interesting, relatively new and with a wide and direct entomological bearing. He leaves behind a science of which, in its application to American types of forests, he has been the father and pioneer. It is fitting and proper at this time to give a brief biographical sketch of Dr. Hopkins, to summarize briefly his great achievements in Forest Entomology and to outline the most notable contributions.

BIOGRAPHICAL. Dr. Hopkins was born August 20, 1857, on a farm at Evans, near Ripley, Jackson Co., West Virginia. From his earliest recollection he was interested in and made collections of, first, land shells and, in succession, water shells, bird eggs, birds, and finally insects, and has, since he was about 12 years old to the present time, specialized on insects. Some work he did on the farm with an insect affecting raspberries, including original drawings to illustrate the insect, its work and

[1]A contribution by members of the Division of Forest Entomology of the Bureau of Entomology, U. S. Department of Agriculture.

its parasites, led to his appointment in 1890 to a position on the staff of the West Virginia University Agricultural Experiment Station.

His love of and indefatigable efforts to understand nature had by this time equipped him in extraordinary fashion for the life he was to follow. As State Entomologist Dr. Hopkins immediately gave evidence of his insight into the entomological problems of the forest and his deep interest in them. He showed the broad knowledge of entomology that leads to a recognition of the value of systematic and biological investigations in their application to economic entomology, building up a collection and a reputation for keenness of vision in the warfare between insects and man. Surely the recognition of forest entomology as a branch of science developed as his accomplishments increased.

In the autumn of 1892 he was sent on a misssion to Germany to find a beetle that would be predaceous on the barkbeetle (*Dendroctonus frontalis* Zimm.) that was killing the pine and spruce timber of West Virginia and adjoining states. The mission, as to the attainment of the object of finding the beetle (*Clerus formicarius* Linn.) was a success as described in Bulletin 56, West Virginia Agricultural Experiment Station, 1899. In recognition of this the Board of Regents of the West Virginia University honored him with a degree of Doctor of Philosophy.

In 1899 he was employed by the U. S. Division of Entomology (now Bureau) to make entomological explorations in the Pacific Coast and Northern Rocky Mountain forests; in 1900 to make a similar exploration in the spruce forests of Maine; and in 1901 to make a special investigation of depredations by tree-killing insects in the Black Hills of South Dakota. In recognition of services on these special missions, and as foremost forest entomologist in America, Dr. Hopkins was, on July 1, 1902, appointed Chief of Forest Insect Investigations in the Bureau of Entomology, which position he has held to the present time.

Dr. Hopkins' first activities as Forest Entomologist consisted of extensive preliminary surveys of the character and extent of the most important depredations by forest insects throughout the country. The results of these surveys and additional studies convinced him of the primary necessity for studies of the Scolytid barkbeetles, especially those in the genus *Dendroctonus*, many species of which he found to be new and the most destructive enemies of coniferous forests in this country.

Since about 1895 Dr. Hopkins has been interested in broad biological questions and in 1900 announced the recognition of a natural law. Of late years he has devoted much time to the development of this law

which is now known as the Bioclimatic Law, a law of life and climate as related to geographical distribution of plants and animals, life and climate zones, etc. To this work Dr. Hopkins expects to devote the rest of his life.

As to his school education, Dr. Hopkins has often regretted that it was limited to the common schools of his native county but for 57 years he has been a student and investigator with nature as his teacher and feels that, although yet a student, he has gained knowledge and experience equaled by few college graduates.

FOREST ENTOMOLOGY IN AMERICA. Forest entomology in the United States was relatively new. Intensive investigation of forest insects being only about a quarter of a century old and so different from the forest entomology in Europe, not only in the types of insects involved but also in the environmental conditions which govern the forests, an almost entirely new problem was to be solved. Furthermore, the value of forest and forest products, as compared with other agricultural crops, was still too small a proportion of our national resources and income for it to receive its full share of support, although our forests, by virtue of their just right, are demanding an ever increasing amount of attention and concern. Nevertheless, in spite of this comparatively short period of research and relatively poor support, much has been done by forest entomologists under the lead of Dr. Hopkins in this country and it is only fitting that what has been accomplished should be recognized in this country as abroad. During the past twelve years many of the British colonial forest entomologists have visited the United States Bureau of Entomology to study methods of combating forest insects.

The destructiveness of forest insects in the United States was early realized by Dr. Hopkins and other forest entomologists and foresters. However, it was found difficult to overcome the popular opinion that barkbeetles were secondary in attack as in Europe and to educate people into realizing their serious primary nature. In the United States certain barkbeetles (species of *Dendroctonus*) are absolutely primary and concentrate on the largest and best timber. They cannot be combated in the same manner as can insects that attack only weakened trees. But Dr. Hopkins was of the opinion from the first that forest insects could be controlled!

The investigators of forest insects in the United States have been considerably retarded in their efforts and progress by lack of financial support. The appropriations for forest insect control have never been equal to those for the control of insects injurious to other crops. Leav-

ing aside appropriations by the states, $30,000 per year has been the average annual appropriation for the Division of Forest Insects of the Federal Bureau of Entomology and this, despite the fact that forest insects undoubtedly kill more merchantable timber in coniferous forests than does fire, for the control of which there are large annual appropriations by federal, state and private timber owners.

Despite this shortage of funds, Dr. Hopkins and his assistants have given due attention to those phases of the subject which have been deemed most important, such as tree-killing barkbeetles and insects injurious to forest products, where there was most need and demand by owners for control methods.

In addition, very complete biological investigations of the principal forest insects of the United States have been made by forest entomologists of the federal and state governments and effective methods of control have been determined for many of the most injurious species.

Foremost, among the many notable contributions made by Dr. Hopkins to the science of forest entomology are the following broad principles regarding the work of combating forest insects in America:

Economic Principles of Forest Entomology

First, *artificial methods* of controlling destructive barkbeetles which include, (a) *the percentage principle of control* by which it is only necessary that enough of the depredating insects be destroyed to turn the balance in favor of their natural enemies; and (b) *the host selection principle* by which it is possible to control an insect attacking a valuable host tree without reference to those in a less valuable host, due to the adaptation of the insect to the host upon which it has fed for many years and the subsequent confinement of its attack to that host.

Second, *silvicultural control and business management*, which will provide for the care of standing timber and the handling of crude and finished products in such a manner as to bring about unfavorable conditions for attack by the more destructive insects. This includes the use of pure stands to prevent the attacks of certain defoliators and mixed stands in other cases; the removal of slash only where logging operations are sporadic or of short duration; and in the case of timber products the utilization of natural elements such as solar heat and water.

Third, the *Bioclimatic Law* as a guide to (a) the proper dates and periods to apply a remedy in any given locality, (b) determine the natural distribution of an insect and (c) the sections of a state or country where artificial distribution from another country or an infested section in this country would be most *dangerous* as related to a destructive insect or most *useful* as related to a beneficial one.

These principles which embody in part silvicultural and forest management practices are being tried out on a large scale and if, after sufficient test, they prove true, they are the most important and economical principles ever advocated. Without such principles in certain inacces-

sible areas of the country, control work against forest insects could never be undertaken.

Artificial control embodying these principles has been carried on extensively both in the east and in our western forests and has resulted in the saving of millions of feet of standing commercial timber from destruction by insects. The control projects which have been instituted on these principles by the Forest Service, Park and Indian Services, state and private owners are too numerous to mention but the success of the methods has been well established.

Removal of 50% to 75% of the infested timber brings about a reduction in the loss of from 60% to 80% in the first year and, as has been recently demonstrated in Southern Oregon and Northern California on the largest project yet undertaken, at a cost which leaves a profit at the end of the first year's work.

On a project in Northeastern Oregon from 1910 to 1913, as a result of extensive and intensive investigations, Dr. Hopkins was able to prove that a case of long standing epidemic infestation of *Dendroctonus monticolae* Hopk. in inferior species of timber such as lodgepole pine will *not* migrate to any extent to another and more valuable host such as yellow pine, although the stands are adjacent and intermingled. This is extremely valuable data since control work in lodgepole pine, especially in inaccessible areas, is often impractical.

Contributions by Assistants of Dr. A. D. Hopkins

Along the line of silvicultural control much important work has already been done. W. F. Fiske, a former assistant of Dr. Hopkins, in 1913, after a study of the favorable food plants of the gipsy moth, advocated pure stands of trees which were unfavorable to the gipsy moth larvae, or in association with less favored food plants. He also found that mixed stands of oak and white pine were only slightly less susceptible to serious damage than pure stands of oak which is the favorite food plant. This was the real beginning of silvicultural control work in this country, although it has long been known to foresters and forest entomologists that, in general, pure stands are more susceptible to their particular enemies than mixed stands. The main difficulties to be encountered in practices embodying pure stands or mixed stands are to be found in the fact that, while a pure stand of one forest tree will be practically immune to the insect for which one recommendation is made, it offers in its turn an exceptional opportunity for wholesale loss from another insect. Hence, it can be readily seen that studies over many years must be made before positive instructions regarding silvicultural

practices from the entomological viewpoint will be available. Indeed, with only a short period of study—some twenty-five years—no more positive results can be expected if they are to be considered as authoritative.

There is no doubt but what similar studies to those made by Dr. F. C. Craighead, a former specialist on forest entomology under Dr. Hopkins, and his successor as Forest Entomologist, on the locust borer could be done with other forest insects, even though it is not yet entirely proven to the satisfaction of foresters and entomologists that this method is entirely effective in the case of the locust borer. Much more work should be done with the locust borer to thoroughly prove that shading the trunks will prevent attack by sunlight-loving beetles.

Notable host plant studies were made by Craighead, and J. M. Miller has made valuable contributions to our knowledge of forest-tree-seed destroying insects.

Along other lines studies have been made by Dr. Hopkins and members of his staff on the periodicity of attack by barkbeetles, endemic and epidemic conditions, distances of flight, slash disposal, solar heat control, etc., and much valuable data accumulated.

Methods for the control of insects injurious to both crude and finished forest products have been determined. Special treatments, such as chemical wood preservatives, sprays, and determination of effective kiln drying temperatures, etc., have been developed by Dr. T. E. Snyder and are in effective use, even to the extent of enabling American manufacturers to compete with foreigners for trade in the Tropics with chemically treated, "white-ant-proof" furniture, etc. Snyder discovered that Lyctus powder post beetles lay their eggs in the pores of wood. By closing these pores by the use of any ordinary filler, attack by these insects can be prevented.

The most important and economical methods, however, are those first recommended by Dr. Hopkins, i. e. of management. With a knowledge of the biology of the insects, it has been possible to slightly change the methods of handling timber so as to create unfavorable conditions for attack by insects. By simple methods of classification of stock in piling, periodical inspection, and utilization of the older stock first, injury to seasoned hardwood lumber and products by *Lyctus* powder post beetles can be and is being prevented, resulting in the saving of enormous stores of hardwood for the Army and Navy.

Certain termites require moisture—shut off from the ground, their source of moisture, by proper construction they will dry up. The

natural forces can be utilized and by rapid transportation of green saw logs from the woods into the water at the mill pond or to sites in full sunlight, as worked out by Dr. Craighead and other members of the division of Forest Insects, damage by borers and ambrosia beetles can be prevented. Green lumber can be protected from attack by the removal of bark edges and loose piling.

Future Needs

While Dr. Hopkins and his staff of forest entomologists have chiefly concerned themselves with what have been deemed the most important and most pressing demands from timber holders for information on the insect enemies of forests, tree-killing barkbeetles that take a large annual toll in healthy merchantable timber, and insects infesting forest products where handling has increased the value of the material; it is true that there exist many problems of comparatively lesser importance which still remain to be solved. Among the most important of these are the defoliators. However, it is also true that this type of insect forms the most fluctuating and least constant menace. The caterpillars and false caterpillars responsible for those sporadic losses which are admittedly great are still not truly constant primary enemies of the great bulk of our timber. Death of the defoliated trees is sometimes due to secondary attack. As a consequence, the defoliators have, for economic reasons, had to yield to the continuous pressure of their more dangerous and destructive rivals.

Close cooperation between foresters and forest entomologists in the study of the possibility of silvicultural and management methods of control of these defoliating insects as has been begun in Canada—will yield valuable results.

Summary

Dr. Hopkins has contributed to the progress of the science of Forest Entomology in at least three distinct ways: He has advanced to a remarkable extent our knowledge of tree-killing beetles as systematist, biologist and morphologist on Scolytid beetles of the world, on which he is recognized as a world authority; established principles of fundamental importance for the economic control of forest insects; organized, led and developed an extraordinary staff of assistants and specialists in the various fields of Forest Entomology. Indeed in the latter connection, while he himself leaves this field the work in which he has so aided, there remain many workers, who, guided and inspired by him, have added much to the knowledge of the problems of Forest Entomology. We may look

to these co-workers, many of whom have not been mentioned and due credit given in this brief account, to continue the work on forest insects so well begun by Dr. Hopkins and we hope that in his newer field Dr. Hopkins will meet with the same success that attended his efforts in Forest Entomology!

THOS. E. SNYDER, *Entomologist.*
WILLIAM MIDDLETON *Assistant Entomologist.*
F. P. KEEN, *Assistant Entomologist.*

Washington, D. C., August 28, 1923.

SEASONAL ADAPTATION OF A NORTHERN HEMISPHERE INSECT TO THE SOUTHERN HEMISPHERE

By JOHN C. HAMLIN, *Officer-in-Charge Prickly-pear Investigations, Commonwealth Prickly-pear Board*

ABSTRACT

Melitara junctolineella Hulst (Order Lepidoptera, Family Pyralidae), one of the several insects introduced into Australia in connection with the attempt biologically to control the prickly-pear pest, is indigenous to North America. In southern Texas it produces two generations annually. Its brood adjustment to seasons was upset by departure from our winter and immediate entry into the summer of the Southern Hemisphere. During the period it has been accomplishing its swing-over to the opposite seasons of Australia three generations have been produced in sixteen months. Complete adjustment to the Australian seasons has not yet obtained but observations indicate that in its ultimate adaptation to the opposite seasons it will have three broods yearly.

On the one hand it is common knowledge that certain species of insects have more or less broods per year as the summer is longer or shorter. On the contrary there is evidence to show that certain species cease activities at certain periods regardless of the conditions of temperature and moisture to which they may be subjected. These instances, however, apply to insects living on the one or the other side of the equator.

When first entering upon duty for the Australian Commonwealth Government, I made many conjectures as to the manner in which certain species from the Northern Hemisphere would adjust themselves to the opposite seasons of the Southern Hemisphere; that is to say where summer is simultaneous with our winter. This adjustment has been kept in mind, and at the present time it is possible to present preliminary data on a yet unsettled adaptation.

The species in point is *Melitara junctolineella* Hulst,[1] an insect indigenous to North America. The larvae feed within the thick joints

[1]Order *Lepidoptera*, Family *Pyralidae*.

of the western prickly-pears, causing large swellings. When full-grown they leave the joints and spin their cocoons beneath fallen segments or other rubbish near the base of the prickly-pear plant. The large sluggish moths which issue from the cocoons mate quickly, deposit eggs as "sticks" and soon die.

During May and June, 1921, stocks of larvae were collected in the vicinity of Uvalde, Texas. The progeny of these insects are still on hand partly in Australia and partly in Texas. Of course, moths emerging from later collected material were mingled with the original lot, but this fact does not affect the developments to be pointed out.

Below is shown the record of the generations of this material from May, 1921 to May, 1923.

RECORD OF GENERATIONS

Year	Month	At Uvalde, Texas, U. S. A.	At Brisbane, Australia.
	May	Emergence	
		Oviposition	
	June		
	July	Larval	On Dec. 6, 1921 a portion of the insects left the U. S. A. and arrived Brisbane, Australia on Dec. 30, 1921. Further happenings to this portion are shown below.
	Aug.	Larval	
1921		Pupation	
	Sept.	Emergence	
		Oviposition	
	Oct.		
	Nov.	Larval	
	Dec.	Larval	Pupated en route
	Jan.	Larval	Emergence
			Oviposition
	Feb.	Larval	Larval
	Mar.	Larval	Larval
	Apr.	Pupation	Pupation
	May	Emergence	Emergence
		Oviposition	Oviposition
	June		Larval
1922			
	July	Larval	Larval
	Aug.	Larval	Larval
		Pupation	
	Sept.	Emergence	Larval
	Oct.	Oviposition	Larval
			Pupation
	Nov.	Larval	Emergence
			Oviposition
	Dec.	Larval	Larval
	Jan.	Larval	Larval
	Feb.	Larval	Larval
1923	Mar.	Larval	Pupation beginning
	Apr.	Pupation	Emergence & oviposition beginning.
		Emergence	
	May	Oviposition	Pupation ending

From the above record of the seasonal history of the species, it will be noted that at Uvalde there are two generations annually. The over-

wintering larvae emerge from late April to early July, reaching the maximum emergence during May or June depending upon the weather conditions. The summer brood develops in a relatively short period and the fall appearance of adults occurs from late August to early November, usually attaining the peak of emergence about the first of October. The progeny of these fall moths pass the winter in the larval condition. Thus, the summer generation requires four months from egg to adult, while the winter brood takes eight months.

Now, a portion of this material was packed with cactus in properly lighted and ventilated cases and shipped via San Francisco, Honolulu, Pago Pago and Sydney to Brisbane, Queensland. The shipment left San Francisco on December 6, 1921 and reached Brisbane at the end of that month. Enroute the cases were placed on the bridge deck of the S. S. Sonoma beneath a canvas canopy which was removed in the early morning each day to allow the sunlight to enter the cases.

The larvae were just one month from the egg on the date of departure from San Francisco. They were of the winter brood which would normally spend about six months in the larval stage.

This shipment of material was opened in the laboratory at Sherwood (near Brisbane), Queensland on January 5, 1922. Practically all of the larvae were found to have pupated enroute, and on January 7, 1922 the first adults issued from the cocoons. Emergence ended on February 1, 1922. Thus, the passage through and into summer weather in the tropics and in the Southern Hemisphere greatly accelerated the development of these winter brood larvae.

It will be noticed, then, that the (now) Australian portion emerged and oviposited in January, 1922, fully five months prior to the emergence and oviposition dates recorded for that portion of material which remained in the native habitat of the species.

Again, the progeny of this first Australian generation completed another cycle about May 18, 1922. Thus, two generations of the Australian material completed their cycles slightly before the normal spring emergence at Uvalde of the portion which remained at home.

The third generation of the Australian portion began about the proper time for the larvae to get started just before the advent of the winter season in Southern Queensland. The emergence of adults of this brood was rather drawn out, probably having been influenced by the upsetting of the normal development of the two previous generations. The adults issued from October 31, 1922 to January 2, 1923.

The fourth generation of the Australian lot numbered several thousand, and emergence of the adults began on April 13, 1923. On May 18, 1923 pupation of this brood was practically completed, so it may be judged that the maximum emergence period would be about the middle of May, 1923.

The fifth generation of the Australian batch may, then, be considered to date from May 15, 1923.

Thus, during the period when the species was accomplishing its swing-over from the seasons of the Northern Hemisphere to those of the Southern Hemisphere, there were produced three generations in sixteen months.

The rapidity of development of the species during midsummer (January-February) in 1923 is shown by the notes on certain cages of the fourth generation material. These cages received freshly deposited eggs about the first of January, 1923 and the adults issued therefrom within three months.

From the reactions to the Australian seasons so far observed it seems that in the ultimate adjustment to seasons, *Melitara junctolineella* will have three generations annually instead of the two which occur in Southwest Texas.

The manner in which such adjustment will be worked out may be seen in the transition period above reviewed. Those portions of a given brood which appear at unfavorable intervals are eliminated, and only that part of the brood which happens to appear at the opportune time will be preserved. Such elimination and preservation should, after a number of generations, accomplish a thorough adjustment of the brood cycle to the seasonal cycle in the new environment.

The observed rapidity of development and the long summer of Queensland strongly indicate that the final adaptation of this species to that environment will be three broods yearly.

The over-wintering generation will probably emerge about the middle of October and complete its cycle in three and one-half months. About the end of January, then, the second brood would begin, and the adults of this generation emerge about the middle of May. The progeny resulting from the May moths would pass the winter as larvae in approximately five months.

A further note of interest regarding this North American plant-feeding insect in Australia is that the adults are noticeably larger on the latter continent.

TOBACCO DUST AS A CONTACT INSECTICIDE[1]

By P. J. Parrott and G. F. MacLeod,

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Abstract

From the data secured during experimental work reported on the following pages, it is concluded that the finer grades of tobacco dust, containing 1 percent nicotine, are highly toxic to the spirea aphis (*Myzus persicæ*). Observations of the spirea plantings under treatment during the past two seasons also indicate that timely applications of fine tobacco dust would afford adequate protection. In comparison with superfine tobacco, dust mixtures containing free nicotine or nicotine sulfate were, on an average, somewhat more effective but the actual difference in toxicity was not marked.

As the tests were made in greenhouses it is not safe to conclude that finely powdered tobacco would prove equally effective against the same insect under normal field conditions. The insecticidal properties, however, are such as to suggest the desirability of more knowledge of the value and economy of the material in combating other noxious species.

In conclusion it should be noted that commercial grades of tobacco show a lack of standardization since they vary greatly in nicotine content and physical properties. Considering the nicotine content of tobacco dust and commercial brands of tobacco extracts in relation to prices, powdered tobacco is apparently more expensive than the commercial solutions.

In considering the merits of dusting as related to orchard management in New York, there is need of experimental data regarding the value of dust mixtures in combating such insects as the green apple aphis, rosy aphis, leafhoppers, redbugs, pear psylla etc. To combat insects of this character there is not a wide range of available substances with desirable insecticidal properties. At present nicotine sulfate is widely used and recently free nicotine has been recommended for the control of certain species. These are certainly the most effective constituents of dust mixtures which function as contact insecticides, but a serious drawback to their extensive employment is their high cost. The situation reveals the desirability of more knowledge concerning the toxic properties of other substances.

Of the materials considered deserving of more serious consideration than has apparently been devoted to it is tobacco dust, and during the past two years the Geneva Experiment Station began a serious investigation to determine its value in combating the common sucking insects of orchard and farm crops. This paper deals largely with the more important results of tests with tobacco dust against the aphis (*Myzus persicæ* Sulz.) on spirea (*Caryopteris mastacanthus*), a plant which is grown extensively in greenhouses of local nurseries.

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[1]Presented at the Meeting of the Division of Agricultural and Food Chemistry of the American Chemical Society at New Haven, Connecticut, April 4, 1923.

The Nicotine Content and Physical Properties of Tobacco Dust

In the Virginia Station Bulletin 208, Ellett and Grisson state "that the nicotine content of tobacco varies greatly, depending upon many factors. The fertility of the soil and the kind of soil both have influence. In curing, the temperature is often allowed to run too high and nicotine is lost by volatilization. To ascertain the amount of nicotine, chemical analysis is required." The nicotine content of Virginia tobacco is as follows: Stems, 0.48 to 0.60 percent; sweepings, 0.73 to 0.88 percent; N. L. Orinoco, 5.35 to 5.62 percent; olive, 3.63 percent; light, 2.9 percent; smoker, 2.30 percent; wrapper, 3.05 percent; cutter, 3.46 percent; dark, 2.83 percent; medium smoker, 3.76 percent; and common smoker 2.47 percent. "Stems had less nicotine content than leaves and dark varieties of tobacco, as Narrow-Leaf Orinoco and Burley, had higher ratios of nicotine than bright or flue-cured types."

There is, apparently no standard for tobacco dust either with respect to nicotine content or physical condition. In comparison with the foregoing figures, it is interesting to note that analysis of various lots of tobacco dust purchased in the State of New York showed considerable variation in nicotine, as follows: Sample 1, 0.88 percent nicotine; Sample 2, 0.58 percent; Sample 3, 0.50 percent; Sample 4, 0.95 percent; Sample 5, 0.98 percent; and Sample 6, 1.00 percent.

A few grades of tobacco dust purchased during the past summer were quite fine, but the larger number of samples contained a considerable amount of coarse material. Most preparations consisted of fine and coarse particles in varying proportions. A common constituent of tobacco was clay or dirt or other cheap adulterant substance or filler.

In our experiments we used a tobacco dust which was guaranteed to contain 1 percent nicotine. The physical properties of this tobacco dust were as follows: Less than 50-mesh screen, 18 percent; 50-mesh, 27 percent; 100-mesh, 1 percent; 150-mesh, 10 percent; and 200-mesh, 44 percent.

To obtain larger amounts than were available of the more finely pulverized material, the tobacco dust was ground for six hours or more in a ball machine. This is not an entirely satisfactory outfit for the purpose because of the large amount of time required for grinding and its failure to pulverize completely all the coarse particles. Regrinding, even with this machine, did improve greatly the physical properties of common grades of tobacco dust. This is shown by comparing the foregoing figures relative to untreated tobacco dust with the accompanying analysis of a sample which was subjected to grinding for several hours:—

Less than 50-mesh, 1 percent; 50-mesh, 11 percent; 100-mesh, 2 percent; 150-mesh, 12 percent; and 200-mesh, 74.5 percent. Supplies of tobacco dust of different degrees of fineness were obtained by passing the reground material thru screens of designated sizes.

Toxicity of Coarse and Fine Tobacco Dusts

In this series of tests commercial tobacco dust and reground tobacco of different degrees of fineness was applied at the rate of 5 grams to each spirea, the material being applied carefully in order to insure thoro treatment. Sheets were attached firmly to the collar of each plant and "tanglefoot" was applied to the edges of the sheets to prevent the insects from escaping. Twenty-four hours after treatment the number of dead and live insects were counted. With the exception of the coarser grades of tobacco dust all or a majority of the insects were usually, dislodged by the applications, and there is little doubt that the plants received greater protection than is indicated by the recorded killing efficiencies. The data are presented in Table 1.

A study of the foregoing data shows plainly that the finer grades of tobacco dust possessed greater killing powers than the coarse preparations. The 200-mesh material obtained from the reground tobacco was superior to other grades in its toxicity to the aphids and in its physical condition. Tobacco dusts of 50-mesh fineness or coarser displayed low killing power and poor adhesive properties.

Effects of Hydrated Lime on the Physical and Insecticidal Properties of Tobacco Dust

Chemical analyses demonstrated that hydrated lime in combination with tobacco dust promoted the liberation of nicotine. Observations also indicated that the incorporation of light fluffy material such as lime hydrate of 200-mesh fineness improved the physical condition of tobacco dust. To determine the influence of these factors a series of tests were undertaken, the results of which are indicated in Table II.

It will be observed that in general the mixing of hydrated lime with tobacco dust resulted in decreased toxicity, and that the loss of insecticidal efficiency increased proportionately with the amount of lime added. Mixtures containing 10 percent lime hydrate were not as effective as undiluted tobacco dust but they were more toxic than those containing 25 percent hydrated lime. On the other hand the physical properties of tobacco dust, especially the coarser grades, were considerably enhanced by the addition of lime hydrate. Altho lime tends to liberate nicotine, its failure to affect appreciably the insecticidal properties of the mixtures

Table I.—Effect of Fine and Coarse Tobacco Dust on *Myzus persicæ*

Grade of Material	Experiment No. 1		Experiment No. 2		Experiment No. 3		Experiment No. 4		Experiment No. 5		Experiment No. 6		Experiment No 7		Total No. of insects	Average Perc't killed
	Total No. of insects	Perc't killed	Total No. of insects	Perc't killed	Total No. of insects	Perc't killed	Total No. of insects	Perc't killed	Total No. of insects	Perc't killed	Total No. of insects	Perc't killed	Total No. of insects	Perc't killed		
Tobacco Dust																
50 mesh mixture	310	27	303	10	320	20	411	14	287	21	342	18			2033	18.3
100 mesh mixture	213	80	367	76	245	77	406	75	345	71	435	74			2006	75.5
150 mesh mixture	312	72	361	70	314	65	487	55	270	68	351	70			2095	66.6
200 mesh mixture	303	71	308	62	312	61	423	52	214	55	354	65			1914	61.0
Reground Tobacco Dust																
50 mesh mixture	295	22	227	36	305	10	420	07	280	06	272	02	422	04	2221	12.4
100 mesh mixture	236	77	256	72	212	65	391	74	386	67	225	70	330	68	2036	70.4
150 mesh mixture	309	70	354	72	420	74	214	87	306	77	277	74	330	76	2219	75.7
200 mesh mixture	339	90	529	94	377	92	260	92	377	95	294	89	415	88	2591	91.4
													Grand Total No. of insects:—		17115	

Table II.—Effect of Addition of Hydrated Lime to Tobacco Dust

Grade of Material	Experiment No. 1		Experiment No. 2		Experiment No. 3		Experiment No. 4		Experiment No. 5		Experiment No. 6		Experiment No. 7		Total No. of insects	Average Perc't killed
	Total No. of insects	Percent killed	Total No. of insects	Percent killed	Total No. of insects	Percent killed	Total No. of insects	Perc't killed	Total No. of insects	Perc't killed	Total No. of insects	Perc't killed	Total No. of insects	Perc't killed		
Tobacco dust with 10% Lime Hydrate	451	96.5	219	93.6	382	90.3	484	89.2	244	86.9	299	90.1	295	91.0	2374	91.1
Tobacco Dust with 25% Lime Hydrate	249	84.6	301	83.1	380	92.2	202	86.1	308	85.7	332	86.6	335	87.0	2107	86.5
Tobacco Dust with 50% Lime Hydrate	329	83.4	393	93.3	272	82.4	328	74.9	376	82.8	357	76.2	275	77.4	2330	81.5
Tobacco Dust	292	95.8	285	98.6	251	92.6	240	96.7	270	92.6	313	93.7	312	96.4	2063	95.2
100 mesh Tobacco	203	60.1	321	78.2	201	82.1	114	74.6	621	75.2	241	81.2	301	71.7	2002	74.7
100 mesh Tobacco and Lime 10%	254	41.6	308	46.1	193	62.4	369	42.9	421	39.9	381	44.7	262	42.1	2188	45.7
150 mesh Tobacco	675	98.4	247	75.7	199	91.5	301	87.7	247	99.2	381	89.5	287	90.1	2337	89.0
150 mesh Tobacco and Lime 10%	237	76.5	222	79.5	210	86.3	373	77.5	287	79.8	341	81.8	369	80.4	2039	78.9
200 mesh Tobacco	380	98.9	434	96.8	373	97.9	214	98.1	320	95.1	294	93.5	259	97.6	2274	96.8
200 mesh Tobacco and Lime 10%	260	97.3	252	94.6	336	96.7	298	94.2	426	95.2	238	92.1	244	93.7	2054	94.8
													Total No. of insects:—		21768	

TABLE III.—RELATIVE TOXICITY OF 1 PERCENT TOBACCO AND NICOTINE DUST ON M. PERSICÆ

Material	Experiment No. 1		Experiment No. 2		Experiment No. 3		Experiment No. 4		Experiment No. 5		Experiment No. 6		Experiment No. 7		Total No. of insects	Average Percent killed
	Total No. of insects	Percent killed	Total No. of insects	Percent killed	Total No. of insects	Percent killed	Total No. ins'ts	Percent killed	Total No. of insects	Percent killed	Total No. of insects	Percent killed	Total No. of insects	Perc't killed		
200 mesh Reground Tobacco Dust 1% Nicotine	343	98.9	378	97.2	264	96.6	227	97.5	314	95.5	321	94.1	286	96.7	2133	96.6
Lime Carbonate with 1% Nicotine	299	99.0	271	98.6	302	99.1	268	100.0	274	98.4	382	100.0	287	99.3	2083	99.2
Lime Hydrate with 1% Nicotine	244	94.9	215	99.2	379	99.1	214	100.0	323	99.6	216	100.0	270	99.4	1861	98.8
Sulfur with 1% Nicotine	362	93.0	254	89.9	326	99.2	260	100.0	305	95.5	251	99.7	373	99.6	2131	97.7
Kaolin with 1% Nicotine	252	77.1	277	79.2	340	80.1	267	76.4	229	85.3	339	74.9	485	76.1	2189	78.4
Lime Carbonate with 1% free Nicotine	550	97.1	484	99.8	591	98.1	602	98.9	332	99.1	213	98.7	290	99.7	3062	98.8
Lime Hydrate with 1% free Nicotine	449	97.2	513	98.1	366	94.5	741	98.5	305	99.7	339	98.6	181	96.2	2894	97.5
Sulfur with 1% free Nicotine	314	100.0	482	94.2	245	98.8	508	97.8	228	100.0	326	99.7	203	100.0	2306	98.6
Kaolin with 1% free Nicotine	240	72.5	398	84.2	222	73.8	284	77.5	224	71.5	236	74.6	234	72.6	1838	75.2
												Total No. of insects —			20497	

TABLE IV.—TOXIC ACTION OF TOBACCO AND NICOTINE PREPARATIONS TO M. PERSICAE

Material Used	Method of Application	Time required To Act minutes	Total No. of insects	Percentage killed
200 mesh tobacco dust	In contact with insects	3.00	426	95.7
200 mesh tobacco dust	Not in contact with insects	15.00	587	100.0
200 mesh tobacco dust with 25% hydrated lime	In contact with insects	2.75	645	92.9
200 mesh tobacco dust with 25% hydrated lime	Not in contact with insects	7.50	472	100.0
Hydrated lime with 1% nicotine	In contact with insects	0.50	451	97.8
Hydrated lime with 1% nicotine	Not in contact with insects	1.00	437	100.0
Check—No treatment	Not in air-tight jar	——	554	00.8
Check—No treatment	In air-tight jar	——	608	00.0

tested may perhaps be explained on the supposition that the evolution of nicotine was slow.

Relative Efficiency of Tobacco, Free Nicotine and Nicotine Sulphate Dusts

This series of tests were designed to show the comparative insecticidal properties of dust mixtures, containing respectively fine tobacco dust, free nicotine and nicotine sulphate. The different preparations contained approximately 1 percent nicotine and were applied at the rate of 5 grams per plant. The results obtained with the dusts are indicated in Table III.

On the whole, tobacco dust did not exhibit as high a rate of toxicity as did the mixtures containing free nicotine or nicotine sulfate, but the difference in insecticidal properties was, however, not very conspicuous. The free nicotine dusts were more rapid in their paralytic action than those containing nicotine sulfate, and tobacco dust was the least rapid in dislodging the insects. The mixtures in which kaolin was incorporated as a carrier of free nicotine or nicotine sulfate displayed a killing efficiency of less than 80 percent, while the preparations using sulfur and lime carbonate or hydrate as carriers of the nicotine were noticeably more efficient.

Toxicity of the Fumes of Dusting Mixtures

To obtain data relative to the toxicity of the fumes given off by the different nicotine dusts, applications of the materials were made to the walls of large bell jars, after which the jars were placed over plants heavily infested with aphids. In making these experiments care was exercised to prevent any of the particles of the various materials from coming in contact with the bodies of the insects. For the sake of comparison several plants were dusted with the same preparations. The data are given in Table IV.

The insects confined in the dusted bell jars exhibited no apparent signs of unrest, while those on the treated plants began to move immediately after the application and seemed agitated. The aphids began to fall from the dusted plants in half the time required to dislodge those subjected only to the fumes arising from the walls of the jars. Notwithstanding the greater speed with which the dusts in contact with the insects acted the final killing was more complete in the case of the enclosed plants. These insects were killed *in situ* and were usually attached to the leaves by the proboscis which had not been extricated at the time of paralysis. It is also interesting to note that only a very few

insects were dislodged from these plants while a larger percentage of the insects fell from the dusted spireas.

THE CONSTITUTION OF OIL EMULSIONS

By E. L. GRIFFIN, *Associate Chemist, Insecticide & Fungicide Laboratory, Miscellaneous Division, Bureau of Chemistry, Washington, D. C.*

ABSTRACT

In an emulsion of mineral oil with soap and water the mineral oil is divided into very small droplets which are suspended in the watery medium. The soap is added to keep these droplets from coalescing and finally separating out. Its action is as follows: part of it is broken down, the fatty acids being dissolved in the kerosene and the alkali remaining in the water; part of it forms a film between the oil and the water, preventing the droplets from coalescing, thus stabilizing the emulsion; and any excess soap remains in water solution and helps the spreading qualities of the spray.

The breaking down of the soap may be prevented, or at least made negligible, by the addition of excess alkali, thus preventing an apparent waste of soap.

Two emulsions of the type used in practice were analyzed and the distribution of the soap in them reported.

The oil emulsions used as insecticides consist of very small droplets of oil suspended in watery media. An emulsion can be formed of oil and water only, but it is unstable and the components soon separate. A stabilizer, usually a soluble soap, is added to overcome this tendency. In the past there has been little or no definite knowledge as to what happens to the soap in the emulsion and just what part it plays in the process of emulsification. There was, therefore, nothing to guide in the preparation of an emulsion except previous experience as to what produced a satisfactory product. When difficulties occurred, and they were not infrequent, there was often no good explanation for them or guide to prevent them in the future.

In a recent paper[1] the fate of the soap in the process of emulsification is shown to be as follows and in the order given.

1. Part of the soap is broken down (hydrolyzed) into the alkali and fatty acid from which it was originally formed and the fatty acid goes into solution in the oil, leaving the alkali in the water.
2. Part forms a layer or film of uniform thickness around the droplets of oil.
3. All of the soap not used in 1 and 2 remains in the water solution.

HYDROLYZED SOAP

Soaps in dilute water solution partially hydrolyze, or break down, into the alkalies and fatty acids from which they were originally made. The

[1]Griffin, J. Am. Chem. Soc., 45:1648 (1923).

fatty acids are very soluble in mineral oils and so are taken up by the oil droplets. This leaves the alkali in the water. The process of hydrolysis goes on until the concentration of the alkali is so great that the tendency to hold the fatty acids in the water in the form of soap is as great as their tendency to go into solution in the oil.

The soap which is thus broken down does not appear to serve any useful purpose and is apparently a total loss. It has been shown experimentally that this loss may be prevented by adding enough alkali to keep the soap from hydrolyzing and freeing fatty acid which would go into solution in the oil. This is in agreement with the work of Briggs and Schmidt[2] who found that small quantities of alkali tended to assist in the formation of emulsions of benzene in soap solution. The fish-oil soap, which is recommended by the Bureau of Entomology for use in making oil emulsions,[3] contains a considerable excess of alkali and is particularly suited to the preparation of oil emulsions. Of course, in the addition of alkali the possibility of injury to vegetation by excessive quantities of it must be borne in mind.

FILMS SURROUNDING THE DROPLETS OF OIL.

If an oil is broken into droplets in water, the droplets readily coalesce and the oil separates out. However, if a soluble soap is present in the water, soap immediately attaches itself to the oil droplets to form films around them. This film prevents the droplets of oil from coalescing and is the essential feature in stabilizing emulsions of this type. It is exceedingly thin; in fact, its thickness is the length of a single molecule of the soap and is the same whether the soap solution from which the film is formed is dilute or concentrated. The quantity of soap necessary to form it is comparatively small. One gram of soap will cover an area of 500 to 1000 square meters, depending on the kind of soap. One very good commercial emulsion contained 66% of oil and had droplets which averaged about 0.0003 centimeters in diameter. These have an area of 2 square meters for each cubic centimeter of oil dispersed. One gram of soap would therefore form the film necessary for from 375 to 750 cubic centimeters of this emulsion. With coarser emulsions (larger oil droplets) less soap is needed. Thus, if the emulsion is 66% oil and has droplets averaging 0.001 centimeter in diameter, 1 gram of the soaps would be used to form the film for 1,250 to 2,500 cubic centimeters of the emulsion.

[2]Briggs and Schmidt, J. Physical Chem., 19:478-99 (1915)
[3]Quaintance and Siegler, Farmers' Bulletin 908, U. S. D. A. (1918).

If not enough soap, in addition to that broken down to fatty acids and alkali, to form the films for the droplets is present, the emulsion will not be permanent. There will be nothing to prevent the droplets from coalescing and the oil will therefore separate out. There need not, however, be a large excess of soap. It is possible to utilize nearly all of the soap from a solution for the formation of film.

Soap Remaining in Solution

The excess soap remaining in solution in the water is of no value in so far as stabilizing the emulsion is concerned. In the application of sprays, however, their wetting and spreading qualities are of very great importance. Soapy water wets foliage and spreads on it much better than water without soap. This is connected with the lowering of surface tension caused by the addition of soap to water. The surface tension of water is very much lowered by the addition of small quantities of soap. Larger quantities do not affect it proportionately. There is probably, therefore, an optimum concentration of excess soap which may be used in the emulsion. This quantity must be determined by experiment.

Experimental Emulsions

To illustrate the partition of the soap in practice, a kerosene emulsion made by the method of Quaintance and Siegler,[4] using commercial neutral sodium fish-oil soap, was analyzed. It contained 1.80% of dry soap. This was distributed in the emulsion as follows: 8% of the soap was lost by hydrolysis and solution in the kerosene; 12% was used in the formation of films to keep the droplets of oil from coalescing; and 80% remained in the water solution.

Another emulsion was made in the same manner, except that a small quantity of sodium hydroxide (about 30 cc. of normal solution per liter) was added to the soap solution. In this case the droplets were slightly larger than in the first emulsion owing probably to variation in the agitation. None of the soap was hydrolyzed. About 9% was used in the formation of films, and the other 91% remained in the water solution.

DELAYED EMERGENCE OF HESSIAN FLY FOR THE FALL OF 1922

By W. B. Cartwright,

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Abstract

A delayed emergence of Hessian fly occurred within a triangular area bounded by the Mississippi and Ohio Rivers and a line drawn eastward from St. Louis. Ab-

[4]loc. cit. p. 28.

normal conditions of temperature and rainfall were the primary causes of this delayed emergence. Normal emergence consisted of two small waves on September 22 and 30 respectively, from which progeny developed normally. The heavy delayed emergence occurred October 27 to 30 from which progeny struggled through the winter with at least a 25% death rate. Infestation by progeny of the late emergence caused total loss of 24% to 38% of wheat plants sowed on the usual recommended dates and some injury to an additional 24% to 37%.

The emergence of the Hessian fly (*Phytophaga destructor* Say) wherever it occurred throughout the East Central States in the spring of 1922 was normal. The fall emergence for this territory occurred as partially regular and in certain areas markedly irregular. This irregular or delayed emergence was centered within the triangular area bounded roughly by the Mississippi and Ohio Rivers and a line drawn eastward from St. Louis, Missouri. It is intended to review the climatological conditions existing from the time of the regular spring emergence to the delayed fall emergence and to discuss the behavior and economic aspect of the latter.

Climatological data of the U. S. Weather Bureau for Illinois and Indiana, the states invaded by the irregular fly brood, show that for July the average temperature was almost normal. For August in Illinois the state average of temperature was not unusual but precipitation was the least since 1897, the deficiency being as much as three inches in places. In Indiana the mean August temperature was slightly above normal and precipitation deficient. September in Illinois was warm and dry with more clear weather than any year since 1897. Deficiency in rainfall ranged from one to four inches south of the Illinois River with practically no rainfall after the 20th. Temperature in Indiana for September was above normal and precipitation deficient and with minor exceptions practically no rainfall after the 20th. For both Illinois and Indiana October opened with high temperature. For Illinois temperature was 10 to 14 degrees above normal from the first to 6th, 10 degrees below normal from the 12th to 17th, and 12 to 18 degrees above from 27th to 31st. For Indiana the second decade was colder and killing frosts occurred in nearly all counties on the 13th, followed by recurrences on the 18th to 20th. The last week was much above normal. Rainfall for both Illinois and Indiana occurred within periods 6th to 11th, 13th to 16th, and 22nd to 23rd and none for the remainder of the month.

The activity of the Hessian fly was continuously observed at Centralia, Illinois and the following data compiled from the records of this place. Drouth was temporarily broken by rainfall on September 10th and 19th, a total of .6 inch. Almost coincident with this period of moisture, adult Hessian flies appeared September 22nd and represented the first wave of

the normal fly emergence. On September 30th another small wave of flies appeared. The source of these individuals was not determined and oviposition was so light that less than 3% infestation resulted in wheat of volunteer status. Pupariation of the progeny of the first wave began October 18th and was completed October 28th, pupariation of the progeny of the second wave began November 6th and was completed November 17th. Thus ended the normal activity of the fly for the fall.

On the night of October 6th a heavy rainfall supplied all fields with excess moisture. An apparent complete transformation of fly larvae was noted October 16th. Adults issued October 27th to 30th and oviposition was heavy. Over half the progeny entered the winter as small larvae. Pupariation began near the middle of January and ceased in general March 1st though naked larvae were found occasionally to April 1st. Pupariation was not completed as death rate ran high through March and ended the tragic struggle. From records made in December and February a 25% death rate was computed for this interval. After this time no definite figures were obtainable, due to the disintegration of infested wheat plants. Concrete data obtained February 23rd showed a 70% pupariation as a whole for the progeny in early sowed wheat. Closer analysis revealed a greater pupariation of not less than 75% for forms existing in growing plants with less than 50% pupariation in dead plants. In wheat representing the general fall seeding a 45% pupariation existed, with dead plants revealing a range of 38 to 54 in percentage of pupariation. On April 4th dead plants which had been infested showed 26% without fly life. Reversion of larvae in the flaxseeds began March 31st and ended near April 12th. Pupariation occurred from April 16th to 29th and adults emerged April 22nd to May 8th

Mr. W. H. Larrimer of the Bureau of Entomology, noted that a transformation of the Hessian fly did not occur in stubble in the central and northern areas of Indiana during October but that practically all of the larvae remained as "hang-overs" in the stubble. To what extent the killing frosts and low temperatures influenced the behavior of the fly remains questionable. A few irregular flies were recorded by other workers of the Bureau of Entomology at points in the wheat area east of the Mississippi River during the heavy emergence at Centralia, Illinois, but in numbers of no consequence. South of the Ohio River the activity of the fly merged into normalcy of the southern area.

The economic aspect of so heavy delayed emergence is important. The droughty condition of August, September, and early October interfered greatly with fall preparation of wheat land. Seed beds which

were prepared and seeded to wheat remained dust-like until the periodic rains of October. Germination of early seeded wheat was irregular and incomplete until after the rains. Too much moisture immediately after the rains delayed sowings. Hence from the general weather conditions most of the wheat did not appear above ground until two weeks after the recommended dates to evade Hessian fly attacks. It was therefore, in an attractive stage for fly oviposition and in the stage in which plants would greatly suffer from fly injury. There was a three-fold struggle through the winter, a struggle of host and enemy, the death of one meant the death or life of the other, and the composite struggle of both to survive the winter coldness. From 24% to 38% of the wheat plants sowed to one week after the recommended dates died. An additional 24% to 37% of plants on good land and land properly prepared and seeded evaded death by the rapid growth of secondary culms. Late sowed wheat lacked heavy infestation of the fly in the fall and missed winter kill.

RESULTS OF AN OIL SPRAY IN TREATMENT OF BOX LEAF MINER (*MONARTHROPALPUS BUXI*) LABOU.

By Jas. K. Primm, and E. A. Hartley, *Bureau of Plant Industry, Harrisburg, Pennsylvania.*

Abstract

The box leaf miner, *Monarthropalpus buxi* (Diptera, Itonididæ) injuries has resulted in a reduced demand for certain varieties of boxwood. A series of experiments indicate limited usefulness for the molasses spray and very satisfactory results were obtained with a heavy emulsifying petroleum oil, 1-20, and a pint of Black Leaf 40 to 50 gallons of spray, making one or two applications.

A decrease in the demand for certain varieties of boxwood, especially *Buxus sempervirens*, is noted among nurserymen in the eastern part of Pennsylvania and is attributed to the unfortunate experiences which people have had with the box leaf miner (*Monarthropalpus buxi*). The encouraging results obtained by the use of sticky applications to the foliage, designed to entrap the adults at the time of emergence and prevent oviposition, have been largely offset by the cost of material and the multiplicity of failures due to heavy rains during the emergence period which washed off the sticky coating, and entailed a second, or sometimes a third outlay for spray material with a lessened prospect of control.

On estates where a noticeable reduction of infestation has been attained by the most generous use of labor and material, how much credit should go to the molasses treatment and how much to other methods

which are used to supplement this treatment is a matter of conjecture. There is evidence, however, that most of these treatments may just as well be discarded as applied by the average owner of boxwood, laboring under the popular misconception that because it worked for Mr. Smith under one set of conditions it should work for Mr. Brown under an entirely different set. There is no doubt that control could be secured whether the material used is molasses, rosin fish oil soap, tobacco extracts, or any other efficient contact spray, if the time and frequency of applications is properly correlated with the emergence period and the varying weather conditions.

In southeastern Pennsylvania adults have been observed emerging as early as April 17th on imported stock from Holland which had just been unpacked from crates and which doubtless had been kept at a warm temperature in transit. In 1921, emergence under natural conditions was first noted on May 1st, and in 1922 pupation was first noted on April 18th and emergence on May 8th. The period of emergence seems to be regulated by seasonal temperatures, and doubtless must be preceded by a settled temperature of 70° to 80° F. for a period of two or three weeks. In the spring of 1920, which was late, the first emergence was noted by Hamilton[1] in the vicinity of Baltimore, on May 19th.

Recent success with fumigation suggests this treatment as the most certain of accomplishing results, but the expense, as well as danger, incident to fumigation with hydrocyanic gas, and the limited period—when the insect is in the pupal state—in which it has been found to be effective will not warrant its use except in the case of very valuable specimen plants. The elements which are lacking in making the molasses treatment of more general value, cheapness and greater resistance to rain, are thought to be found, in the experience of the writers, in the use of a heavy emulsifying petroleum oil. Its capacity for entangling the adults and checking oviposition is fully as efficient as in the molasses treatment, as indicated from the results of our field experiments in the spring of 1922. The product used is manufactured by the Sun Oil Company, and is free from any animal or vegetable fats. It has a Baumé registry of 16 to 17 degrees and viscosity of 1200 at 70° F.

The outcome of a number of preliminary experiments with various materials to ascertain their effect on the foliage of boxwood with a view to killing the larvae in the leaves or of causing the foliage to drop, was negative, but it was in the incidental use of this oil as a spreader for "Black Leaf 40" that its extremely viscous and adhesive properties were

[1]Jour. Econ. Ent., Vol. 14, No. 4, August 1921, pp. 359–365.

first demonstrated. A few plants were then sprayed with one part of oil diluted with twenty of water and were left for observation. Little foliage injury followed and when thoroughly dried there was left a heavy oily blanket which was evenly distributed over both the old and new growth and which did not wash off in a heavy rain.

Because of the large number of heavily infested boxwood on one of the private estates near Philadelphia, the cooperation of the superintendent was obtained and a long section of hedge of *Buxus sempervirens* was reserved for treatment with this oil. Preparations were made to spray the bulk of the boxwood with resin fish oil soap (ten pounds to fifty gallons) and "Nikoteen" (one pint to fifty gallons of the soap solution). A large nursery also adopted this treatment, using "Black Leaf 40" instead of the "Nikoteen." It was discontinued by both parties after a few applications and the remaining sprays consisted entirely of the oil solution. A neighboring estate proposed to spray its boxwood with a good grade of "black jack" molasses (one part to three of water) and "Black Leaf 40" (one part to 264 of the molasses mixture). A commercial firm undertook the fumigation of about fifty fine specimen box on the latter estate with a guarantee of its success. The first applications of spray were given on May 9th, the day after the emergence of the first adults. In all of the oil applications (1-20), "Black Leaf 40" was used (one part to 500 of the spray).

Counts were made the first three days after the applications of the spray to determine the comparative number of adults which had emerged successfully, with the number found trapped in the spray and the number of extruded pupae which failed to emerge successfully. Similar counts were taken from twigs of bushes sprayed with the resin fish oil soap and the molasses mixtures. The final percentages of control are based upon counts made the following July of the number of eggs successfully hatched, as it was found a large percentage of the eggs which were deposited in both the treated and check plants were either infertile, or else did not develop from other causes which were not ascertained. The checks in each case were untreated plants of a similar degree of infestation as the plants which were treated. The oil spray was applied by the writers with a small compressed air sprayer; the molasses and resin fish oil soap sprays were applied by workmen on the estates with a barrel pump outfit.

OIL APPLICATIONS

Exp. 1. Sprayed *May 9th* with "Sun Miscible Oil" (1-20) and "Black Leaf 40" (1-500).

Exp. 2. Sprayed *May 9th & May 11th* with "Sun Miscible Oil" (1–20) and "Black Leaf 40" (1–500).

Exp. 3. Sprayed *May 9th* with "Sun Miscible Oil" (1–20) and "Black Leaf 40" (1–500), and on *May 12th* with "Black Leaf 40" only, (1–500).

Exp. 4. Sprayed *May 9th & May 12th* with "Sun Miscible Oil" (1–20) and "Black Leaf 40" (1–500) and again on *May 20th*, with the same, following a heavy two-day rain on May 17th and 18th.

Exp. 5. Sprayed *three times* as in Exp. 4. The preceding experiments were confined to sections of the hedge, the latter to a heavily infested isolated bush, much taller and with more open foliage than in the case of the hedge.

RESIN FISH OIL SOAP, MOLASSES AND GAS TREATMENTS

A. Sprayed with resin fish oil soap (10 lbs. to 50 gallons) and "Nikoteen" (one pint to 50 gallons of soap solution) on *May 9th & 10th*.

B. Sprayed with molasses (1–3) and "Black Leaf 40" (1–264) on *May 11th*. No adults emerged on this bush until May 10th.

C. *One application* as in B., and *two succeeding ones* following rains on May 17th & 18th which washed off those preceding.

D. Fumigated by commercial firm with hydrocyanic gas *May 6th & 7th*, three hours exposure each time. Dosage not known. Many miners still in larval stage.

E. Fumigated as in D once only, on *May 10th*. Three hours exposure. Dosage not known. Most of miners in the pupal stage.

The following tabulation shows the counts made to determine the relative number of adults successfully emerged, adults trapped in the spray, and those killed by contact before emergence was complete. No counts were taken from parts of bushes from which counts had previously been taken.

TABLE I.

Exp. No.	Counted	Successfully emerged	Trapped	Killed by contact
Oil Applications				
1	May 10	120	150	166
1	May 11	391	392	120
1	May 12	315	152	30
2	May 12	527	486	163
3	May 13	55	40	37
4 & 5	No counts			
Other Treatments				
A	May 10	27	7	112
A	May 11	230	16	274
A	May 12	222	4	39
B	May 13	45	40	140
C	No counts			
D	May 11	0	565 dead; 77 alive	Checks, all
E	May 11	0	1029 dead; 2 alive	emerged

The oil sprays (Experiments 2–3) accounted for a high percentage of trapped adults, and the efficiency of the nicotine is shown by the large number which were unable to emerge successfully and were killed by contact. The resin fish oil soap spray (Treatment A) possessed very little merit in entangling the adults, but the addition of nicotine sulphate

as in the oil sprays, greatly increased its efficiency. The diminishing power of the tobacco extracts is noted on the third day when the relation of the number killed by contact to the number successfully emerged, is seen to be very much smaller. The maximum emergence was not reached until two or three days after the last count was made. As the resin fish oil soap failed to check them after the third day either by trapping the adults or killing by contact, without fresh applications, the workmen changed to the oil treatment and further experimental value was therefore complicated. The molasses treatment (Treatment B) yielded less data for comparison, as most of the plants having a high infestation had first been fumigated, or had been fumigated before much emergence had taken place. The counts were taken from one small bush, and at a time when comparatively few adults had emerged, but would indicate a good control. A steady rain through the 17th and 18th washed off the spray, however, and on the day following, when the bush was unprotected, swarms of adults emerged and oviposited in the leaves. Two more applications were given after an interval of two or three days, but only 15.4% control was obtained (See Table 2, Treatment C). The hydrocyanic gas treatments (Treatments D and E) yielded very promising results, but should not be construed in favor of this treatment without qualifications. The high kill in Treatment E is probably due to the fact that a large percentage had reached the pupal stage, rather than in a perfection of the treatment. The 79 individuals recorded as alive in both treatments were larvae. Furthermore, a very high temperature was generated in the tent during fumigation, which the operator claimed was due to some secret process in connection with the treatment. A maximum and minimum thermometer which was placed in one of the tents during fumigation, went to its limit, 130° F. All the tender young growth was killed back. Experiments using heat as a treatment probably would yield some interesting results

TABLE II.

Exp. No.	No. of leaves infested	No. of larvae in infested leaves	No. of leaves uninfested	Percent kill
2	150	200	3300	91.0
Check	774	1474	1389	
3	189	262	2793	87.1
Check	774	1474	1389	
4	646	1087	6183	86.0
Check	2381	5513	2369	
5	313	392	2776	92.0
Check	1147	2787	610	
C	588	920	1009	15.4
Check	774	1474	1389	

The above tabulation shows the counts of newly hatched larvae

taken from the treated and check plants and the percentages of theoretical kill obtained by the various treatments. All the counts were taken in July. Twigs were taken at random, stripped carefully of every leaf, and the counts taken from these leaves.

The large counts made in order to obtain the above percentages, and the large scale on which these sprays were used, especially in treating thousands of valuable nursery boxwood, will greatly strengthen the foregoing results. So many varying conditions, such as exposure of the plants, different varieties, close or open growth, shade and sun, number of applications given, etc. afforded every opportunity for studying the effect on the plants and whether oil sprays of this type could be applied safely without a number of qualifying precautions. Outside of the slight spotting, noticeable the first day or two after the application of the spray, no perceptible signs of injury could be observed, and at this writing (Oct. 2, 1922) the treated plants are in a fine healthy condition. The results of the experiments would indicate that one or two applications of the oil at a strength of one part to twenty of water, with the addition of a pint of "Black Leaf 40" to fifty gallons of the spray mixture, given about the first of May or shortly before the beginning of emergence, will be sufficient to greatly reduce an infestation, and that a repetition of the treatment will not be necessary even after forty-eight hours of hard rain. If the first application is a thorough one, the second one should probably follow in about one week, or just before the height of the emergence. A low pressure is advisable in applying the spray.

KERNEL SPOT OF PECAN CAUSED BY THE SOUTHERN GREEN SOLDIER BUG

By William F. Turner, *Georgia State Board of Entomology*

Abstract

Kernel spot proves to be a physiological trouble, resulting from the feeding of Hemiptera, particularly *Nezara viridula* L. As a result of such feeding the tissue of the kernel breaks down for a short distance around the puncture, resulting in a hemispherical discolored portion. This becomes bitter and imparts its bitterness to the whole kernel. Only the kernel is affected and the trouble cannot be detected until the nut is cracked. The insects can cause kernel spot only during the period when the kernel is hardening. They do not breed on pecans; only the adults feed on the nuts. Cowpeas and soybeans, being important breeding hosts, should not be used as cover crops in the orchards.

Kernel spot of pecan is, as the name indicates, an affection of the kernel. When the spots are few in number they are nearly round, as seen on the surface; when abundant, thru running together, they become irregular. At first the spots show only the slightest discoloration; later

they commence to darken and in time become very dark brown in color. This discoloration may also extend beyond the limit of the actual "spots" in severe cases. A horizontal section of the spot is almost a semicircle, the diameter being the surface of the kernel, showing that the spot is actually a more or less perfect hemisphere. This hemisphere is very distinct in that, at an early stage, it is outlined in brown, and later the entire affected area becomes discolored. An examination of the spot, in section, shows that the cells are all collapsed, giving a gross appearance of sponginess. One other characteristic is that a majority of the spots occur on the ridges of the kernels; i. e., on the portion nearest the shell. At first the affection seems to have no effect upon the flavor of the nut but after a short time the spot itself becomes bitter and this bitterness is finally imparted to the entire kernel.

Kernel spot usually affects only those varieties which have the thinnest shells, and plump meats. Thus Schley and Curtis nuts are frequently attacked very severely, as much as 50% of their crop being ruined, while such varieties as the Stuart (thick shell) and Frotcher (non-plump meat) will escape injury, though growing next to the susceptible varieties.

The trouble is of very serious importance to the growers of pecans. True it occurs only in slight amounts during most years but occasionally as in 1916 and 1921, in Georgia, fully a quarter of the crop is affected in many groves. Furthermore the losses are particularly severe in that no indication of the trouble can be seen until the nuts are cracked. As a consequence quantities of nuts are shipped in perfect good faith by the growers and pass thru the channels of trade until they reach the final consumer. The finding of spoiled nuts immediately reacts thru retailer and wholesaler to the grower and in most cases the latter is obliged to recall his product. Thus there is a loss not only of the crop itself but of the freight both ways and the good will of the public. Had the grower known of the trouble in the beginning the nuts could have been sold, at reduced prices to be sure, to the crackeries.

Very little has been published concerning kernel spot. This is probably due to the fact that the trouble has not been a major one every year. Rand first gave the trouble some attention.[1] He stated that kernel spot was a fungus disease and isolated a fungus, *Coniothyrium caryogenum* Rand, which he pronounced to be the causative agent.

In 1916 the writer observed what appeared to be a correlation between kernel spot and the use of cow peas as a summer cover crop. Several

[1]Rand, Frederick V., 1914. Some diseases of pecans. In Jour. of Agr. Res., Vol. 4. pp. 303-338.

growers noted the same phenomenon.[2] A study of the situation revealed the fact that the peas were heavily infested with the Southern Green Soldier Bug, *Nezara viridula* Linn., and that these bugs were also present to some extent on the pecans. These observations together with the fact that thin shelled varieties with plump meats were more subject to the trouble than were those which had thick shells, led to the thought that there might be a connection between the insect and the "disease."

In 1917, the writer conducted a few preliminary experiments, caging the bugs on clusters of seedling nuts. While far from being conclusive these experiments indicated very strongly that the suggested relationship was an actual one. There was no indication, however, as to whether the spot was an injury due directly to the insect or the insect acted as the carrier of a disease.[3]

In 1921 Demaree conducted a much more extensive experiment along similar lines. He attacked the problem from the pathologist's standpoint, his main purpose being to determine, in case the suggested relationship was confirmed, if the actual cause of the trouble was a disease or simply an injury directly due to the bug. Demaree's work showed conclusively that kernel spot is caused by the feeding of *Nezara viridula*, this feeding resulting in the extraction of all liquid from a hemispherical area centering about the point of attack, with a resultant collapse of the cells affected; and that no fungus or bacterial organism is concerned in the trouble.[4]

During the past season experiments have been undertaken to clear up several other points with regard to the relationship of the insect to the spot. For this series, some hundred cages were put in place during the second week in August. The varieties of pecan used were Frotscher and Teche; these varieties being chosen for reasons of accessibility altho they are not as subject to kernel spot, under normal conditions, as are many others.

Commencing on August 21, five adults of *Nezara viridula* were placed in each of 10 cages and left for a period of about 10 days. They were then removed and other insects were placed in 10 more cages. This process was followed throughout the season till harvest time. The cages were not removed until the nuts were gathered. In each case, when insects were introduced into cages, nuts were cut and photographed

[2]Credit for the first observation of this apparent correlation belongs to J. B. Wight, a pioneer grower of budded pecans, of Cairo, Ga.

[3]Turner, William F., 1918. Nezara viridula and kernel spot of pecan. In Science n. s., V. 47, No. 1220, pp. 490–491.

[4]Demaree, J. B., 1922, Kernel spot of the pecan, and its cause. U. S. Department Agr. Bul. 1102.

to show the condition of the shells and kernels. At harvest time all nuts were gathered and examined.

The following table gives a résumé of the results obtained in this experiment. The actual dates given in the table are only of general importance. These would vary in any one year, according to the variety under observation, since the ripening period varies considerably with different varieties. The time would also vary from year to year according to seasonal variations. The stages of growth and maturity of the nuts, as indicated by the photographs, give an index which will hold true for all varieties and all seasons.

TABLE I

Series	Cages	Date	No. Nuts	Results
I	1-10	8/21-9/1	24	All nuts dropped off, no spots.
II	11-20	9/1-9/11	23	All but five nuts dropped; all show spots
III	21-30	9/11-9/20	22	All kernels had spots; total of 117 spots.
IV	31-40	9/20-10/4	21	All kernels had spots; total of 187 spots.
V	41-50	10/4-10/12	26	13 nuts with spots (50%); total 83 spots
VI	51-60	10/12-10/19	29	1 nut with spot; 1 spot.
Check	61-100	Harvest	136	No spot.

In studying this table it is necessary to correlate the results with the condition of the nuts. These are shown in plate 6. In series I all nuts dropped from the stems. This is clearly due to the insect attack in that none of the nuts in the check cages dropped. An examination of these nuts after they had been off the tree for some ten days did not reveal any evidence of kernel spot whatever. Plate 6, fig. 3 shows the condition of the nuts at the beginning of this period and figure 4 that at the end. It will be noted that the true condition for our consideration is most nearly like that in figure 3, in as much as the nuts all dropped within five days of the time when the insects were introduced. At that time the shell was still very soft and thin. The skin of the kernel was formed, but none of the meat, this still being in liquid condition.[4] As a result of this condition there was nothing in the kernel in which a spot could form.

In the second series 18 out of 25 nuts dropped (72%). All of these, together with the nuts which remained on the tree, developed spots. Figs. 4 and 5 on plate 6 show the condition of the nuts at the beginning and end of this period. In figure 4, the kernels have begun to form on the inside of the skins. At the end of the period a very marked development has taken place altho the kernels are still far from plump. Through-

out this period the kernels were sufficiently formed to allow of the development of the spots.

During the time of the 3rd and 4th series, in which 100% of the nuts were affected (and none dropped), figures 5 to 7, plate 6, the shells were still fairly soft; the nuts with plenty of meat for attack; but the meats were not at all mature, and liquid could be extracted with the resultant collapse of the cells.

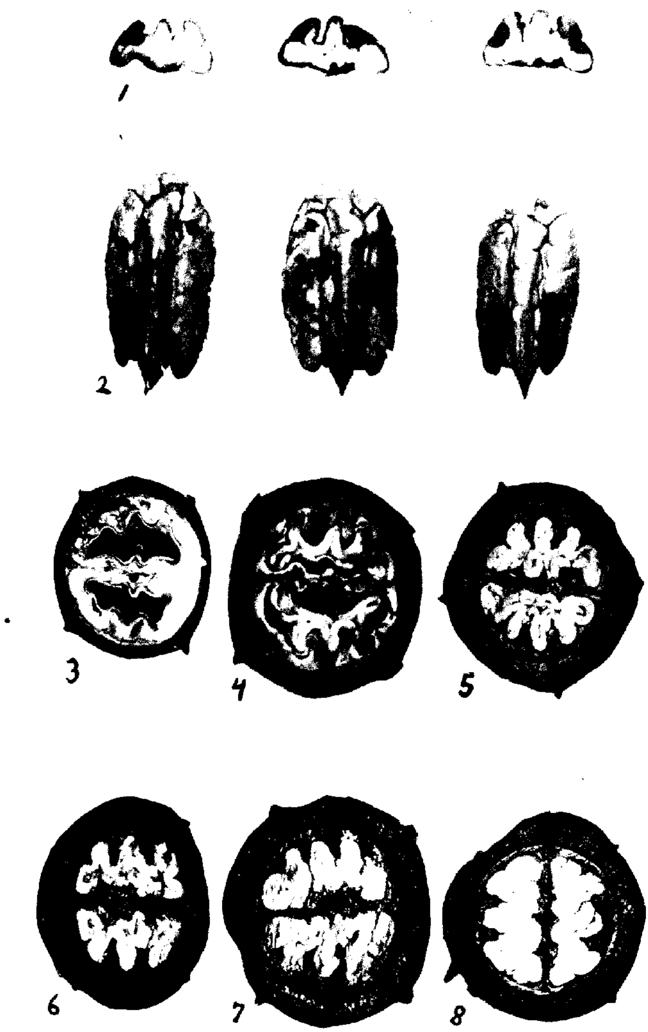
From the time the kernels commenced to mature, figures 7 to 8, the percentage of affection decreased. There was no change of appearance in the spots formed in this 5th period and the number per nut did not decrease materially. The nuts of course varied somewhat in their rate of development and the results obtained simply indicate that at the beginning of this period 50% of the kernels were so well hardened that feeding by the insects failed to empty the cells or to break down their walls.

After the stage shown in figure 8, kernel spot could not be produced by the insects. In series VI only one spot was produced, and this was on a kernel which was obviously not as mature as the other nuts of the series, at the time of examination.

The adult insects fed very freely on the nuts, up to the time of harvest. Even after the shucks had split the insects continued their attack, forcing themselves between the loose shuck and the shell and thrusting their beaks directly through the shells. The bugs are able to pierce the shells even when these are so hard that it requires considerable strength to crack them, as when they are ready to be harvested.

Kernel spot is caused only by adult insects. Nymphs in the last instar were confined in several cages. Of these only one was able to molt and no spots occurred on any of the nuts. Some twenty batches of eggs laid by females in the cages, were allowed to remain and hatch, naturally. All of the young molted once, since they do not feed in the first instar, but of over twelve hundred nymphs only four reached the third instar; and these died in that stage.

This brings out a very interesting point that while the pecan is a feeding host of the bug, it is not a breeding host. The insects breed most freely, in South Georgia, on legumes, and of these cow peas, soy beans and mung beans appear to be the favorites. Other common breeding hosts are okra, and cotton. Various observers have reported the species as attacking practically every garden and field crop grown in the south but, unfortunately, no attempt has been made to distinguish between breeding hosts and feeding hosts, so a complete list of the former can not be given at present.



Pecans Injured by Southern Green Soldier Bug

1. Cross section of spots. 2. Spots as seen from the surface. 3, 4, 5, 6, 7, 8 sections of nuts gathered Aug. 21, Sept. 1, 11, 20, Oct. 4 and 12 respectively.

After it had been proven that kernel spot was purely a physiological breakdown following the feeding of a bug, it seemed quite possible that other species might have the same effect. With this point in view six adults of a species of Euschistus were confined in two cages and eleven adults of *Leptoglossus phyllopus* F. were confined in three cages. The results are given in table No. 2.

TABLE II

Insect	Cage No.	No Nuts	No. Spots
Euschistus Sp.	1	2	4 & 12
"	2	2	0
L. phyllopus	1	3	0, 9 & 9
" "	2	5	0, 0, 0, 2 & 4
" "	3	3	1, 3 & 1

The spots caused by these two species appeared to be exactly like those following the attack of *N. viridula*, and these results simply confirm the conclusions already reached, as to the nature of the trouble. From the practical standpoint the interest of the grower should still be confined to the Green Soldier Bug, since that is the only species which has been found in sufficient numbers to cause any economic injury.

One thing has impressed the writer most strongly during the study of this trouble, and more particularly in the study of the literature concerning the Southern Green Soldier Bug. This is the lack of careful study directed toward an understanding of, not only this species, but of the Heteroptera in general. There seems to be no doubt that such study will solve many of our present problems as well as many of those of the plant pathologist. The field is practically a virgin one and I believe offers the best opportunity to the beginner in Entomology today.

A NOTE ON THE HONEY DEW PRODUCTION OF THE APHID, *LONGISTIGMA CARYAE* HARRIS

By WILLIAM MIDDLETON, *U. S. Bureau of Entomology*

ABSTRACT

Observations on the aphid, *Longistigma caryae* Harris, at Washington, D. C., showed that it remained active, excreting honey dew, later in the year 1922 than had been previously recorded. Weather reports reveal late excesses of temperature associated with this record and a brief summary of reports of the occurrence of the species with some extracts from literature are included.

During the latter part of October a number of complaints of annoyance by honeydew were received at the Bureau of Entomology, U. S. Department of Agriculture, from residents of Washington, D. C., Jersey City, N. J., and Philadelphia, Pa. Some examinations of trees in certain sections of the Capitol City were made on October 26, 1922, and a large aphid, *Longistigma caryae* (Harris), was found to be abundant in clusters along the under sides of large limbs on a number of sycamore shade trees. Specimens from Jersey City showed the same aphid and a brief description of a louse associated with the Philadelphia complaint agrees with this species though not to an extent permitting a positive determination. At Washington, D. C., the trunks and branches of a number of sycamores and the side-walks and fences beneath showed decided traces of the sweet liquid excreta of the aphids and a cluster low on the trunk of a young sycamore was observed to show some fresh globules of honeydew although the day was cool. Further, the dropping of this material from the trees in certain sections of the city soiled the clothing of passersby and automobiles parked and passing beneath and attracted some unwelcome insect visitors.

On the 14th of November the aphids were still present in masses and a yellow jacket (*Vespula* sp.) was observed flying about those on the young sycamore where there was still some trace of fresh moist honeydew on the bark.

Since there seems to be no previous record for production of honeydew by this species of aphid at this geographical position (Latitude 38° 53′ 17″ N. Longitude 77° 1′ 34″ W. of Greenwich, Altitude 160) so late in the year, the observation should be worth recording and it may be of interest to review the weather conditions at Washington, D. C., during the months of September, October and early November as a factor probably contributing to this possibly unusual occurrence. The summer had been warm and dry and arranged below are the weekly average temperatures, precipitations and excesses or deficiencies for the period mentioned.

TABLE I.—DISTRICT OR STATION OF REPORT, WASHINGTON
(From "Weather, Crop and Markets" Pub. weekly by U. S. Dept. Agric.)

Date of Publication 1922 Week	Period of Average	Average Temperature (±)	Total Precipitation (±)
Sept. 2	(Week ending Aug. 29)	72 (—1)	0.4 (—0.5)
" 9	(" " Sept. 5)	75 (+3)*	5.5 (+4.8)*
" 16	(" " " 12)	76 (+6)*	1.1 (+0.2)*
" 23	(" " " 19)	69 (+1)*	1.1 (0)
" 30	(" " " 26)	65 (—1)	0 (—0.8)
Oct. 7	(" " Oct. 3)	65 (+2)*	0 (—0.6)
" 14	(" " " 10)	72 (+11)*	1.0 (+0.4)*
" 21	(" " " 17)	61 (+3)*	0.2 (—0.4)
" 28	(" " " 24)	53 (—2)	0.1 (—0.8)
Nov. 4	(" " " 31)	52 (0)	0 (—0.8)
" 11	(" " Nov. 7)	55 (+5)*	0.1 (—0.6)
" 18	(" " " 14)	53 (+6)*	0 (—0.6)

In the above review of the weather the preponderance of plus or excess averages (those indicated by the *) are doubtless of especial significance in the late activities of the *Longistigma*. Not only were these apparently favorable to the aphid but they probably produced a stimulating effect on and an increase of sap in the trees which the previous rather scanty rainfall had depressed.

Bureau of Entomology notes[1] of various years on *Longistigma caryae* Harris contain the following records of occurrence for the species.

April 30	August 6, 7, 11, 17, 20 and 28
May 5	September 4, 5, 9, 9, 14, 17, 17, 21, 27 and 29
June 9 and 26	October 16 and 25
July 7 and 24	November 4

These notes point to a maximum appearance during August and September, and while recording the presence of the aphids as late as November, still show no observations on its production of honeydew on this date in the latitude of Washington.

Clarke[2] records the species in early November of 1906 at Montgomery, Alabama, (Latitude 32° 21′ N. Longitude 86° 25′ W., Altitude 222) on the undersides of limbs of sycamores. The colonies were large and honey dew abundant. Townsend[3] observed this aphid abundant on western plane trees at Washington in 1888. His note mentions the staining of the pavement beneath infested trees both in September and October. Davis[4] has recorded *L. caryae* present during October in northern Illinois but does not mention it's honeydew production at this time. Wilson[5] states that at Washington, D. C., he has observed egg-

[1]Kindly furnished by Dr. A. C. Baker.
[2]Clarke, Warren T. Ent. News, Vol. 18, pp. 187–188.
[3]Townsend, T. Insect Life, Vol. 1, No. 6, Dec. 1888, pp. 197–198.
[4]Davis, John J. Jour. Econ. Ent., Vol. 3, p. 413.
[5]Wilson, H. F. Can. Ent., Vol. 41, 1909, p. 385.

laying females as late as December 2 but includes no information concerning honeydew production at this time of year. Weed[6] records sexed forms in late September and in entire October but makes no mention of late honeydew production. Finally Sanborn[7] reports the aphid enduring all temperatures to 0° F. but gives no information regarding its production of honeydew at low temperatures.

According to the information in the Bureau of Entomology files this species of aphid has a wide range of host plants but the above record of its late production of honeydew at Washington, D. C., is made only from observations in which sycamore served as the host.

LIFE HISTORY OF *MICROMUS POSTICUS* WALKER[1]

By C. R. CUTRIGHT, *Ohio Agriculture Experiment Station, Wooster, Ohio*

ABSTRACT

The Hemerobiid larva, *Micromus posticus* Walker was collected with other aphid predators, the life history worked out and an estimate of its economic status made.

While collecting aphid predators in the field during the summers of 1921–22, a Hemerobiid larva was noticed quite often. A number of these were brought into the laboratory where they were bred out, the adults proving to be those of the brown lacewing, *Micromus posticus* Walker. An attempt was then made to obtain literature dealing with this insect but nothing except the description of the adult and a few casual notes dealing with the larva were found.

REARING

The eggs that were brought in from the field were placed in vials closed with a cotton plug. As soon as they hatched the young larvae were transferred to inverted petri dishes where they were provided with aphids as food. This method of rearing was very successful but one difficulty was encountered. The first instar larvae are very small and the exuviae can not be detected by the naked eye. In order to determine the time of ecdysis it was therefore necessary to make a microscopic examination of the contents of the dish each day. In order to have a smaller quantity of material to examine the young larvae were placed on white paper and a very small, thin watch glass inverted over them. Aphids were then introduced independent of any plant tissue. Exami-

[6]Weed, Clarence M. Insect Life, Vol. 3, pp. 286–287.

[7]Sanborn, Charles Emerson. Kans. Univ. Sci. Bull., Vol. 3 (1904) p. 30.

[1]Contribution No. 71, from the Dept. of Zoology and Entomology, Ohio State University.

nation of everything under the watch glass could then be made with little trouble and in this way the number of larval instars was established.

Life History

The eggs are found on the underside of the leaves of plants, usually those that are infested with aphids but not always. They are placed in irregular groups, containing one to thirteen eggs each, some may touch but others may be a centimeter or more apart. The long axes of the eggs frequently parallel each other but exceptions to this are almost the rule. They lie perfectly flat on the leaf surface to which they are rather insecurely attached. There is no sign of the egg being stalked. Eggs were collected in the field from June to the first of October. Though never abundant a few hours search would usually bring several to view.

Females that were confined in cages with aphid infested plants placed the eggs in the same relative position as those found in the field. When they were confined in vials or in petri dishes the eggs were deposited on the nearest convenient surface regardless of what it was or of its position relative to light.

Several incubation records were taken in August and September. The average length of time required for hatching is four days with variations of only a few hours, more or less, from this period.

The larvae are easily the most conspicuous of the different stages. Their usual habitat is, as might be expected, plants that are infested with aphids, where they are found on the lower surfaces of the leaves or running up and down the stems. I have collected them usually on herbaceous plants. Banks states that they are common on aphid infested trees where they are found on the leaves.

The larvae, in hunting for food, move about the leaf changing direction frequently. If the movement is slow the tip of the abdomen is usually attached to the leaf, the legs carry the body forward till it is stretched out as far as possible. The tail is then released, the abdomen is humped up and the tip re-attached. If the movement is rapid the abdomen is carried elevated, not touching the leaf, usually being humped about the fourth and fifth abdominal segments. All the time that movement is going on the head is continually being shifted jerkily from side to side. This is a very characteristic action on their part.

The palps and jaws seem to be the structures used in locating food. The antennae touching the aphid bring very little response on the part of the larva. When a live aphid is located the head is drawn back and then thrust sharply forward, the mandibles piercing the body wall. I

believe this thrusting motion to be necessary on account of the comparative straightness of the mandibles. Were they more curved a pincher-like action might be used. After a hold has been secured by the mandibles violent struggles and extrusions of glue on the part of the aphid usually fail to secure its release. The larvae hold on tenaciously, bracing themselves with their feet, and frequently anchoring themselves by the tip of the abdomen. Every cast skin or sucked out aphid body that is encountered in the search for food is attacked as though it were alive. Skins such as these frequently become caught on the mandibles in which case the larva will wipe its jaws across the surface of the leaf in order to rid itself of them. Occasionally the aphid is held high in the air on the points of the mandibles for several minutes while feeding is in progress. Also if the larva is disturbed it will hold the aphid in this manner while running away.

A first instar larva will require from two and a half to three and a half hours in destroying a half grown cabbage aphid. Larvae of the third instar will destroy them in from five to fifteen minutes depending on the size of the aphid.

In addition to aphids the larvae have been found feeding on the eggs of Coccinellids and of the cabbage butterfly, also on those of their own species. Feeding on their own eggs does not usually take place if all eggs are of the same oviposition period as these hatch almost at the same time. However if two different groups of eggs are placed together the larva of the group first hatching invariably find and destroy the eggs of the second.

The larvae have only three instars. The method used in determining this point has already been described under rearing. Table I is the record of sixteen larvae that were carried from egg to adult. It includes the length of the incubation period, the length of each individual instar, and of the inactive period spent by the larva in the cocoon before the final moult to the pupal stage. Averages and totals for the table are included.

From Table I we find that the first instar averages two and a half days in length, with a maximum of four and minimum of two days. The average length of the second instar is one and a half days with a maximum and minimum of two and one respectively. The third instar is much longer averaging four and a quarter days but over half of this period is spent in spinning the cocoon and lying inactive before the final moult. The total larval period averaged slightly over eight days with nine as the maximum and seven as the minimum length.

TABLE I.—LENGTH IN DAYS OF EGG STAGE, LARVAL INSTARS, AND PUPAL PERIOD OF *Micromus posticus* WALKER

Larva number.	Egg	1st Instar	2nd Instar	3rd Instar active	and Pre pupal period	Pupa	Larval stage	Egg to adult	Preoviposition period	Egg to egg
1.	4	2	1	2	2	5	7	16		
2.	4	2	1	2	2	5	7	16		
3.	4	2	1	2	2	4	7	15		
4.	4	2	2	2	2	5	8	17		
5.	4	2	2	2	3	4	9	17	3 days	20
6.	4	2	2	2	3	4	9	17		
7.	4	3	1	1	3	5	8	17		
8.	4	2	2	1	3	5	8	17		
9.	4	2	2	1	3	5	8	17		
10.	4	3	2	1	3	5	9	18		
11.	4	3	1	2	3	3	9	16		
12.	4	3	1	2	3	3	9	16		
13.	4	3	1	2	2	4	8	16	4 "	20
14.	4	2	2	2	2	4	8	17		
15.	4	4	1	2	2	4	9	17	3 "	20
16.	4	3	1	2	2	4	8	16		
Totals	64	40	23		68	64	131			
Averages	4	2½	1½		4¼	4	8+			

Table II constitutes the feeding record of the sixteen larvae from which the data were obtained for Table I. Figures at the top of each daily square show the number of aphids available as food and those at the bottom give the number destroyed. (See next page)

The following tabular summary of Table II is given showing the average, the maximum, and the minimum number of aphids eaten in each stage.

	Ave.	Max.	Min.
First Instar	10	16	4
Second "	11	21	3
Third "	20	28	3
Total period	40	56	27

The averages show that feeding is about the same in the first two instars and that the third practically doubles these two in amount of food consumed. The small amount of food used is especially noticeable when it is compared with the larval feeding records of the Coccinellids, where averages of from one hundred to six hundred aphids destroyed are not uncommon.

After the third instar has progressed several days (see Table I) the larva spins a very loose meshed almost circular cocoon which will measure from seven to eight mm. in diameter. This will correspond roughly to the length of the larva, as it is spun without curling up. We now have a structure somewhat resembling two saucers placed together, concave surfaces joining with the larva inside. This outer cocoon is really a

TABLE II. LARVAL FEEDING.

Larva No.	Aug. 12	Aug. 13	Aug. 14	Aug. 15	Aug. 16	Aug. 17	Aug. 18	Aug. 19	Aug. 20	Aug. 21	Aug. 22	Aug. 23	Aug. 24	Aug. 25	Aug. 26	Aug. 27	Aug. 28	Aug. 29	Aug. 30	Aug. 31	Sept. 1	Sept. 2	Sept. 3	Sept. 4	Sept. 5	Sept. 6	Sept. 7	Totals	1st Instar	2nd Instar	3rd Instar
1	6 2	5 5	6 3	10 10	10 10			P																				30	7	3	20
2	5 2	8 7	6 6	11 11	18 16			P																				42	9	6	27
3	8 5	10 9	14 13	8 8	13 12			P																				47	14	13	20
4	5 5	5 4	6 5	6 5	7 7	10 9			P																			35	9	10	16
5						6 5	8 7	8 7	9 9	9 32				P														31	5	14	12
6						21 4	11 10	12 11	21 20	23 11				P														56	4	21	31
7								8 6	13 9	15 9	14 3				P													27	15	9	3
8								18 8	17 8	33 21	16 16	29 2			P													52	15	21	18
9								11 5	13 10	10 7	9 9	17 0			P													31	15	7	9
10								6 1	11 5	15 2	10 10	23 22	9 6			P												46	6	12	28
11													5 2	6 5	8 2	10 10	16 11				P							30	7	12	11
12													8 6	10 9	11 3	11 11	18 11				P							40	15	3	22
13																7 5	11 9	7 6	12 12	10 8			P					40	14	6	20
14																8 8	9 6	10 10	22 19	11 8			P					51	8	16	27
15																6 5	10 4	6 6	10 8	17 16	7 7			P				39	15	8	23
16																10 9	10 7	12 10	9 9	12 12			P					47	16	10	21
																									Average totals			40	10	11	20

framework to support the inner, which is now constructed. The larva doubles or curls up and now spins an oval, much more closely meshed cocoon which may be placed either along the sides or in the center of the outer one. It will measure about 5 mm. in length by 2.5 mm. in width. The larva can be distinctly seen through both of these loose silken envelopes. Three to four hours will be used in spinning the outer case. Construction on the cocoon proper is slow and it is hard to tell exactly when work on it ceases.

The silk is spun from the anus, the larva moving the tip of the abdomen hesitatingly back and forth, up and down, and changing the position of the body frequently.

After two or three days in the cocoon the final larval moult takes place (see tables) and the pupa stage proper commences. The shriveled exuvium remains at the tip of the abdomen.

The place of pupation has not been accurately determined. It is probable however that it rarely takes place on the plant on which the larvae have found their food. Two things lead me to believe this; first, though I have constantly looked for them in the field, that is on plants, I have never found the pupa. Second, several larvae in the third instar were placed on plants infested with aphids. When ready to pupate they left the plant and pupated under some card board that was used to support the base of the "chimney" cage. It is probable therefore that the larva pupates under clods, stones or refuse or possibly in the soil.

The pupal periods for sixteen individuals are shown in Table I. The average length of time required by this group for transformation was four and a fourth days.

In emerging the pupa works its way out through one end of the cocoon and through the outer envelope, the emergence of the adult taking place on the outside or within a few mm. of the cocoon. So loosely are the two envelopes woven that the path of emergence is hard to see.

The adults are more active at dusk but may be seen flying in dense shade and on cloudy days. On bright days they are usually found resting quietly on the undersides of leaves and are not easily disturbed.

I have noted them as most abundant on herbaceous plants, such as rape, etc., and also on white pine infested with *Dilachnus strobi*. None have been observed feeding in the open. In the laboratory where adults were kept without food for several days feeding would take place during the day when aphids were given them.

The adults are practically always found on or about aphid infested plants or trees. A few have been taken early in the morning on the

outside of windows where they had evidently been attracted by the heat radiating from within.

Mating has not been observed and is evidently either a very short or a nocturnal operation. It is of interest to note that copulation does take place, as is proven by the hatching of the eggs, in such a limited space as that under an inverted petri plate.

Records of the preoviposition period were secured in three instances. Two of these were three and the other was of four days in length. The individuals making these records are shown in Table I.

The place of oviposition in both the field and the laboratory has already been discussed. The following egg-laying records were secured from females confined under petri dishes.

TABLE III.—EGG RECORDS OF *Micromus posticus.*

																				Totals
No. A	0	0	0	38	68	0	0	0	0	0	Dead.									106
" B	0	0	0	0	21	19	31	11	0	0	"								Dead	82
" C	0	0	0	0	18	12	42	46	21	18	3	16	3	13	34	8	6	2	0	246
																			Average	144

Table III gives a difference of from eighty-two to two hundred and forty-six eggs per female with an average of one hundred and forty-four each. The period over which the eggs were laid is of interest, in one case lasting only two days while in another it extended over two weeks. The number of eggs laid indicates that the insect has fair reproductive powers and but for weak spots at other points in the cycle would be much more common.

Observations made on the feeding of the adult seems to indicate that the rate is little higher if any than in the case of the third instar larvae where the number of aphids destroyed daily averaged about ten.

The following table deals with the length of life in the adult.

TABLE IV.—LENGTH OF ADULT LIFE

Adult No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Days Alive	8	14	21	35	35	36	32	32	10	11	19	6	10

From the above we find that the average length of life was twenty-one days. All the above individuals were reared in captivity during the months of August and September. It can only be guessed that adults in the open live for a longer time but it is probable that they do.

In the spring adults have been noted on aphid infested white pine during the month of April. Table I shows that the period from egg to egg may be passed over in twenty days. If we consider the breeding season as lasting from May until October we have a possibility of four, five or even more generations. The number of generations combined with the reproductive ability of the females should produce a large

number of individuals during the course of the season. No great increase however was noted in the field.

The adults probably overwinter. In support of this supposition three adults were taken in the field about the middle of October. These were placed in an outdoor cage and fed as long as aphids were obtainable in the open. On the twentieth of December two of the adults were still alive though freezing weather had been the rule for several weeks. When next examined on Jan. 2, these two were dead. The fact that they lived for a period of over two months in the open, under winter conditions would seem to indicate that some individuals would successfully overwinter. There is also a possibility that the pupa overwinters but the extreme frailty of the case seems to be an objection to this idea.

No parasites have been reared from any stage of this species nor have any signs been noted that would indicate parasitism. As far as we have been able to find there is also freedom from disease.

Descriptions

Since this work has been completed, the egg and all immature stages of *Micromus posticus* have been described and illustrated by Dr. R. C. Smith. (See Annals of the Entomological Society of America Vol. XVI, No. 2, p. 145-146 and Plate VII). The adult was first described by Walker in "The British Museum Catalogue of Neuroptera," p. 283, 1853. Descriptions are also found in "A Synopsis of the Neuroptera of North America," p. 204, 1861, by Hagen and in "The Transactions of the American Entomological Society," Vol. XXXII, p. 45, 1906, by Banks. In this publication it is mentioned as common throughout the eastern and southern United States. It is also stated that the larvae are found usually on trees and that about ten days are required for their development.

Economic Importance

In the neighborhood of Columbus and Wooster during the past two summers this insect was of little economic importance in controlling aphids. Many counts of aphid predators taken in the field showed that in numbers this species was far in the minority. Attention may also be called to the low rate of feeding that is common to both predaceous stages. Banks ('06) states that they are common on aphid infested trees but the word common may be used by the collector in a far different sense from what it would mean if used by an economic entomologist. The number of eggs per female and the several generations per year would lead us to expect that the insect would increase rapidly during the

breeding season. This however did not seem to be the case. The adult insect is rather fragile and it is thought that storms might work considerable destruction among them. The same might also be said of the first and second instar larvae which are quite frail. It is known that the first instar larvae can not live as long without food as can Coccinellid larvae. Other factors of weakness are unknown.

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A VALUABLE SNAIL POISON

By A. J. BASINGER, *Assistant Entomologist, California State Department of Agriculture, Sacramento, California*

ABSTRACT

A mash made of one part calcium arsenate and sixteen parts bran was used successfully as a poison bait in eradication work against *Helix pisana* at La Jolla, California. It is now giving splendid results in the control of *Helix aspersa*.

During a campaign to eradicate a foreign snail, *Helix pisana*, that was gaining a foot-hold at La Jolla, California, we succeeded in developing a very valuable snail poison that has proven successful not only against *Helix pisana* but also against the Brown Snail, *Helix aspersa*. This is an European species of wide distribution in America and of considerable economic importance. In conducting a series of experiments to determine the best means of combating *Helix pisana* we tried a mash composed of calcium arsenate and bran which we adapted from Lovett and Black[1] who used calcium arsenate and chopped lettuce leaves in the control of slugs. The calcium arsenate and bran proved so potent a weapon against *Helix pisana* which now is practically anihilated that we attribute a large portion of our success in the campaign to this poison. *Helix aspersa* occurred also in the same areas treated for *pisana* and now it, too, is scarce in those areas. There is no doubt but that other species of snails could be controlled by the same remedy.

The poison is made up at the rate of one part of calcium arsenate by weight to sixteen parts of bran. The ingredients are thoroughly mixed dry and then water is added to make a moist but not wet mash. It

[1]Lovett and Black, The Gray Garden Slug. Oregon Agricultural College Experiment Station Bulletin No. 170, June 1920.

must be dry enough so that it will scatter nicely when tossed out with the hand. The infested areas should first be sprinkled with the garden hose, where water is available, as this brings out the snails and keeps the mash moist and palatable. It is preferable to do this in the evening. The poison bait is then broadcast over the infested areas as in sowing grain. It is desirable to toss it lightly over plants so that particles of the poison bran will lodge on the foliage as well as on the ground. The application should be followed each evening for four or five days by a wetting with the garden hose unless the work is done during rainy weather. The poison is very stable and does not loose its efficiency even after being wet each evening for a week or more. We gathered some of the dried particles of poison bran from the ground after it had been wet every evening during six days and it proved fatal to snails that fed on it. This is a slow acting poison and the results from an application should not be judged until two or three days later.

In an experimental plot we secured a kill of 96% out of 6431 active *Helix pisana* in six days. The results during our practical applications were fully as satisfactory. In a treatment applied to a flower bed infested with *Helix aspersa* 86% of a total of 588 snails were dead from the poison at the end of three days. This percentage would have been much higher had the experiment been continued two or three days longer. The following is a copy of a letter from a man in charge of an estate of about ten acres at Pasadena, California, who used the poison bait for *Helix aspersa* according to the directions given herein and was kind enough to report the results.

"Dear Sir:

The day following your visit to our place at the above address I prepared and carefully broadcasted the preparation for the extermination of snails over the entire canyon and the flower gardens. This covered the areas where the snails were the most plentiful. We followed this work during the following week with very liberal spraying over the entire area each day as much as possible and I am glad to report that the result is very gratifying. In fact it is better than I had hoped for. During the past three days I have spent my entire time in cleaning out leaves and old plants through this part of our grounds and have found hundreds of snails and out of the many hundreds only two that were alive. One was in the vegetable garden back of the house where you found the large snail that you took with you as a specimen and the other on a branch of an oak tree.

Very truly yours,
A. H. Gregory
1504 So. Marengo Ave., Pasadena, California.

This poison bait is now being distributed in considerable quantities through the office of County Horticultural Commissioner R. R. McLean

in San Diego County, California, for the control of the Brown Snail. Being simple, inexpensive and efficient we feel that it may be used to advantage in other parts of the country and perhaps on other species of snails.

Scientific Notes

A Tingid attacking quince. In June the writer observed several quince trees, the leaves of which were noticeably injured by the feeding of Tingid nymphs and adults. The leaves were mottled with brown and in some cases almost entirely brown as a result of the feeding punctures.

Adults were submitted to Prof. C. J. Drake who identified them as *Corythucha cydoniae* Fitch.

J. R. STEAR

Ormenis pruinosa Say—A Fulgorid on Apple and Peach. This Fulgorid was quite common on apple and peach in Cumberland Valley orchards this season. The white woolly nymphs clustered along the twigs resembled woolly aphids in appearance and were frequently mistaken for them. No injury was observed as a result of their feeding. Reared adults were determined for me by Prof. J. G. Sanders.

J. R. STEAR

Chambersburg Laboratory, Penna. Bur. of Plant Industry

Swarms of Cotton Moths: Swarms of the cotton moth, *Alabama argillacea* Hubn., appeared in Bridgeport, Conn., September 12. According to the newspapers they were so abundant in the streets as to cause the skidding of automobiles which crushed and passed over them. Be that as it may, they fluttered over and rested upon the show windows and flew into the faces of pedestrians and automobilists. Mr. Zappe observed them resting on light posts and the walls of buildings all over the city. They literally covered the posts of the "white way" lights in Bridgeport, and he also observed them in Stamford. The moths were also present in New Haven, though much less abundant. In 1911 a similar swarm of these moths occurred in New Haven the last week in September, and in 1912 the moths also appeared, though in much smaller numbers and not until October 11 and 12.

W. E. BRITTON

The European Earwig in California: The writer wishes to announce the discovery on August 31, 1923, of large numbers of the European earwig, *Forficula auricularia* Linn., in West Berkeley, California. The origin of the infestation is not known but it is claimed by residents of the infested area that it has been under observation for at least four years. As yet no apparent damage has resulted from its presence and it would not have been reported had it not been for the fact that great numbers collected on the front porch of one of the residences during a vacation period. So repulsive were these to the owner that a few specimens were sent in for identification. The specimens were compared with those received from Seattle, Washington, in 1916, and proved beyond a doubt to be the European species.

The infestation has been reported to the State Department of Agriculture in view of the seriousness of the earwig menace in Oregon as reported by A. L. Lovett

in the *Oregon Grower*, August, 1923. According to Professor Lovett the earwig is a real menace to agriculture as well as a household nuisance of the first magnitude.

E. O. Essig

***Scutellista cyanea* Mot. recovered at New Orleans, La.**—Those familiar with the literature of this parasite will recall that it was liberated to attack the barnacle scale, *Ceroplastes cerripediformis* Comst., at Baton Rouge, La., in 1897 by Dr. H. A. Morgan then entomologist of the Louisiana Experiment Stations. The original material was sent to Dr. Morgan from Washington, D. C., by Dr. L. O. Howard who had received it from Dr. Leonardi in Italy; and Mr. Alexander Craw in 1903 also sent to Dr. Morgan a quantity of *Saissetia oleae* Bern., parasitized by Scutellista from California.

Dr. Morgan states in correspondence with Mr. Ed. Foster of the Louisiana State Department of Agriculture and Immigration that *Scutellista cyanea* was liberated only at Baton Rouge, La., and in July of 1897. Careful searches made several years after liberation failed to reveal a single individual. It was therefore supposed to have died out, and this, its first recovery after more than twenty-five years and at a point over 110 miles distant from the place of liberation, seems very remarkable.

The rather light infestation of the black scale, *Saissetia oleae*, on *Nerium oleander* and varieties in this city, led the writers to make a short inquiry as to the part which parasites might be playing in holding this scale in check here. Accordingly, liberal quantities of oleander branches infested with black scale were collected and caged on May 4, 7, 10, and 12, at which times many exit holes could be seen in the scales; in some instances living parasitic larva and pupae could be found by removing scales at random, and one scale thus removed contained three pupae. As a result numerous parasites emerged on May 11th and on subsequent dates up until June 20th, shortly after which time the cages were discontinued due to drying of the material. These parasites were identified as *Scutellista cyanea* Mot., which identification was later confirmed by Mr. Gahan of the United States National Museum.

About 80 or 85% of the black scale on oleander in New Orleans seem to be parasitized by this insect.

H. K. Plank
Thos. F. Catchings

An Outbreak of *Amorbia humerosana* Clem. on Apple: A serious outbreak of the Leaf-roller, *Amorbia humerosana* Clem. has been found in York County, Pennsylvania. The species has been present in small numbers for a number of years and attention was previously called because the insect might probably become an apple pest. The writer has collected the species from apple from ten counties in Pennsylvania. It feeds also on Poison ivy, Spice bush, Pine and Huckleberry. The injuries resemble those of *Eulia velutinana* Walk. but the scars are larger and deeper. The species is one brooded, the larvae mature towards the end of August or first of September. They winter as pupae and the adults issue in April and May of the following year.

S. W. Frost, *State College, Pa.*

An Important New Pest of Beets in Porto Rico. *Disonycha laevigata* Jacoby is the determination given by Mr. G. E. Bryant, of the Imperial Bureau of Entomology, of a Chrysomelid which has recently become very abundant in Porto Rico. The beetle is about 4.5 mm. long, bright orange-red in color, with eyes, antennae except two basal segments, apical half of tibiae and all of tarsi, black and finely pubescent; the elytra bright green, shining and impunctate. Dr. E. A. Schwarz

states that there are specimens of this beetle in the National Museum collected many years ago in Jamaica. The writer first noted it feeding on the leaves of cultivated beets at Haina, Santo Domingo in 1920, and the first record in Porto Rico is feeding on the leaves of *Amaranthus* spp. at Guanica, Aug. 16, 1921. In December, 1922, a young planting of beets at Rio Piedras was entirely destroyed by these beetles, and a month later millions of them were found on the leaves of young plant cane and bean plants at Guanica. *Amaranthus* spp. are common weeds in these fields and large amounts of the normal host had been destroyed in preparing the fields for cultivated crops. The beetles were not feeding on the bean or cane leaves, merely hiding or resting on them. During the winter the beetles became very abundant about Mayaguez, attacking "beets, chard, eggplant and many other vegetables," and Prof. R. E. Danforth assigned the working out of their life-history to his advanced students in Entomology at the College of Agriculture there. In June, the writer noted a number of blackbirds, *Holoquiscalus brachypterus* (Cassin), walking about the shore of a small saline lagoon at Hatillo, and on closer examination it was found that they had presumably been attracted by the large numbers of this beetle feeding on a weed, *Philoxerus vermiculatus*, which had been defoliated and killed out over a considerable area by them.

George N. Wolcott

The Cave Cricket, Ceuthophilus, as a Possible Vector of Pathogenic Organisms. During the past summer spent at a camp on Lake May (or "Goose Pond" as it is called by the natives), near Lee, in the Berkshire Mountains of Western Massachusetts, the numerous cave crickets (Ceuthophilus) found crawling about in the open privies characteristic of the camps on the lake, attracted my attention. Since cave crickets similar to those found in the privies were observed walking over the food on pantry shelves, it occurred to me that these insects are a potential menace under camp conditions, and I have been greatly surprised to find no reference to Ceuthophilus in the rôle of a vector of pathogenic organisms, in the literature on insects and disease available to me at this time!

People in ill health frequently resort to mountain camps to recuperate, and under such conditions, it would be expected that the excreta in the privies would in some instances be contaminated with the bacilli of intestinal tuberculosis, or even of typhoid fever, and similar pathogenic organisms occurring in the digestive tract of human beings. It is quite conceivable that Ceuthophili walking over such contaminated material, and later finding their way to the kitchens and pantries near by, might readily contaminate any food over which they might crawl; and if such food were eaten uncooked, it is quite possible that infection might result, especially in persons whose resistance to disease was weakened, and who had come to the mountains in a "run down" condition, to rest and recuperate.

Since Ceuthophilus is usually a crepuscular or nocturnal wanderer, one is usually unaware of the numerous crickets prowling about his pantry shelves, and this doubtless accounts for the fact that we do not hear more about the danger of these crickets carrying disease under camp conditions. It seems to me, however, that the menace is a very real one, and the rôle of Ceuthophilus as a potential vector of pathogenic organisms under rural conditions, is a subject worthy of further investigation.

G. C. Crampton, Ph.D.,
Massachusetts Agricultural College, Amherst, Mass.

The Oriental Peach Moth (*Laspeyresia molesta* Busck.). Since the note appearing in the August number of the JOURNAL, several serious outbreaks of this pest have been found in Pennsylvania. Through the efforts of Mr. E. M. Craighead of the Niagra Sprayer Company, several serious infestations have been found in the vicinity of Collegeville, Pa. Twenty-five percent of the early varieties and sixty percent of the late varieties show injury. The injury in the latter case is so serious that it will not pay to market the fruit. Orchards in the vicinity of York, Pa. show from ten to twelve percent injury. The pest has been found in noticeable numbers in York, Adams and Franklyn counties, Pennsylvania. The larvae of the fourth generation pupate chiefly at the stem end of the fruit. Some adults issued on September 7th making preparations for the fifth generation. On the bearing trees the injury was found most serious on the fruit, while on the non-bearing trees the injury was confined to the terminal shoots.

S. W. FROST, *Pennsylvania State College.*

THIRTY-SIXTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

The thirty-sixth annual meeting of the American Association of Economic Entomologists will be held at Cincinnati, Ohio, December 29, 1923 to January 2, 1924, inclusive.

Details in regard to the exact place of meeting or concerning hotel headquarters are not available at this time as final arrangements have not been completed.

The Section on Apiculture will meet at 10 A. M., Saturday, December 29. The Section on Horticultural Inspection will meet at 1.30 P. M., on the same day.

The opening session of the general association will be held at 10 A. M., Monday, December 31st. On that evening at 8 P. M., the meeting of the Insect Pest Survey and Extension Entomologists will be arranged.

Applications for membership should be filed with the Secretary as soon as possible and should be accompanied with a fee of $3.50. Blanks can be secured from the Secretary or the chairman of the membership committee.

A. F. BURGESS, *Secretary,*
Melrose Highlands, Mass.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

OCTOBER, 1923

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication, at $3.00 per page for all matter in excess of six printed pages; in the case of other matter, the maximum of 2,500 words is still operative. Photo-engravings may be obtained by authors at cost.

Separates or reprints, if ordered, when the manuscript is forwarded or the proof returned, will be supplied to authors at the rates given below. Note that the number of pages in a reprint may be affected somewhat by the make-up, and that part of a page is charged as a full page. Carriage charges extra in all cases. Shipment by parcel post, express or freight as directed.

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A greatly depleted supply of lumber and high prices have brought all phases of the forestry problem to the front. There are highly developed systems for fire protection in some areas and large sums are being expended for reforestation. Both of these are extremely desirable, yet insects, as shown by the investigations of Dr. Hopkins, are responsible for greater losses in our forested areas than the more spectacular fires. Comparatively little has been done in the development of practical methods for reducing insect depredations in woodlands. This is something that must come in the near future and is being developed in portions of the United States and Canada, work in the latter country being stimulated largely by the extensive depredations of the spruce bud worm.

The resumé given on preceding pages of this issue is a most fitting tribute to an earlier worker. It should result not only in giving credit where credit is due but also serve to call attention to an exceedingly important and difficult line of work which should receive more attention from entomologists. The extensive planting of young trees in connection with reforestation programs is resulting in more problems, since experience has shown that certain insects are not slow to take advantage of the situation. Forest entomologists must develop methods which will make the new plantings reasonably safe from injury as well as devise means for reducing insect injury to the older growth and various forest products. Insects affecting shade and park trees have so much in common with forest insects, that the two should not be separated. It is illogical to spend large sums for fire protection of woodlands and for reforestation, both highly desirable, and allow these efforts to be nullified to a great degree by preventable insect depredations. In other words, a chain is no stronger than its weakest link. Can the entomologist aid in making a stronger chain?

Reviews

Manual of Entomology with Special Reference to Economic Entomology, by H. MAXWELL LEFROY, Professor of Entomology, Imperial College of Science and Technology, pp. i-xvi, 1-541, 4 plates and 179 text figures. Price, $11.75. New York, Longmans, Green Co.: London, Edward Arnold & Co., 1923.

The author in elaborating a portion of his lecture course on economic entomology has given a general account of all groups of insects with special reference to their immature stages, biology and economic importance. He emphasizes identification, a prerequisite to efficient control in many cases. His personal acquaintance with the faunæ of temperate and tropical climates makes possible an unusually comprehensive and authoritative volume, the value of which is not lessened by occasional reference to American insects.

The treatment is upon a systematic basis and largely by groups with comparatively little attention to individual species. The discussion of the 1500 Scolytidæ or Ipidæ, for example, being limited to less than two pages. The volume is suggestive rather than exhaustive and unlike many American works, there are no extensive bibliographies, the author limiting himself to brief citations of catalogues or monographs, thus compelling the student to use such bibliographic aids as *Zoological Record*, *Genera Insectorum* and the *Review of Applied Entomology*.

The book is designed for use with a collection and compels actual acquaintance with insects. There are no keys for the identification of species and the relatively few illustrations simply give assistance here and there, although the salient characters are given for each group. The author recognizes 26 orders, the accounts of the Protura and Zoraptera being particularly welcome.

There are hosts of facts in this rather large, concisely written volume of much interest to entomologists throughout the world, and though primarily British, it has a much broader scope.

E. P. F.

Insecticides and Fungicides, Spraying and Dusting Equipment, A Laboratory Manual with Supplementary Text Material, by O. G. ANDERSON and F. C. ROTH, pages i-xvi, 1-349, 70 figures. John Wiley & Sons, Inc., New York, Chapman and Hall, Limited, London, 1923.

Part I of this volume is a laboratory manual on insecticides, fungicides and appliances. It consists of 172 pages devoted to laboratory exercise on insecticides, fungicides, combination sprays, miscellaneous materials, such as weed killers, whitewash and sterilization by steam, fumigants, spraying equipment and cost problems, designed to give practical experience in the preparation of materials and a good idea of the nature of spraying and dusting apparatus, citations of the more important literature being given with each exercise. It is an admirable laboratory manual.

Part II, pages 173-334, includes comprehensive accounts of methods of controlling nsects and plant diseases and extended and very practical discussions of sprayingi and dusting equipment, cost of operation and directions for operating a gas engine,—literature being freely cited.

The general reader will find much of practical value in Part II, especially orchardists. The impartial up-to-date, discussion of spraying and dusting should be extremely valuable to many large growers. We have in this volume a comprehensive, authorative discussion of numerous practical phases of pest control. The book should not only be in the hands of students, but also in all horticultural libraries and upon the shelves of most fruit growers and others more or less directly concerned in the control of insects and fungi.

Current Notes

Mr. H. G. Barber of Roselle, N. J., worked at the U. S. National Museum during the month of July.

Dr. Carl J. Drake of the Iowa State College and Station has recently recovered from a severe attack of pneumonia.

Mr. Harold C. Hallock has accepted an appointment in biological work with parasites of the Japanese beetle at Riverton, N. J.

Professor Z. P. Metcalf, Professor of Zoology and Entomology in the North Carolina State College and Entomologist of the North Carolina Experiment Station, has been appoined Director of Resident Teaching in the College of Agriculture.

Mr. S. A. Rohwer of the U. S. National Museum, recently spent a few days comparing specimens in the collections in the American Museum of Natural History, New York, and in the Philadelphia Academy of Natural Sciences.

Mr. Oliver I. Snapp of the U. S. Peach Insect Laboratory, Fort Valley, Ga., addressed the forty-seventh annual meeting of the Georgia State Horticultural Society at Cornelia, Georgia, August 23, on "Spraying Materials and Practice."

Professor J. S. Houser attended the joint summer field meeting of the Ohio and Pennsylvania State Horticultural Societies, which included an automobile tour of orchards and vegetables garden in western Pennsylvania and eastern Ohio, July 31–August 3.

A popular lecture on the subject of "Chiggers" was given by Professor T. H. Parks from the radio broadcasting station WEAO at Columbus, Ohio, August 2nd. This comprised part of an entertainment program put on by faculty of the Ohio State University

Professor W. C. O'Kane is Secretary of the New Hampshire Academy of Science. At the fourth annual meeting of the Academy, Professor J. H. Gerould read a paper on "Lethal Hereditary Factors in Butterflies."

Dr. Roland F. Hussey and his wife (Dr. Butler) have been appointed to positions in Washington Square College, a branch of the College of the City of New York. Both received the doctorate at Bussey Institution last June, and both will teach zoology.

Mr. H. S. Adair who has been assisting with plum curculio studies at the Peach Insect Laboratory of the U. S. Bureau of Entomology at Fort Valley, Ga., has been appointed Junior Entomologist in the Bureau to assist with pecan insect investigations at Thomasville, Ga.

Dr. J. Munroe, Forest Entomologist for the British Forestry Commission, and who is attending the Imperial Forestry Conference, visited the Entomological Branch, Ottawa, Can., on July 23rd, and spent a considerable part of his time with the officers in the Division of Forest Insects.

Mr. Carl Heinrich of the U. S. National Museum recently visited the collections of the American Museum of Natural History, New York, to study the Kearfott types of microlepidoptera, and also the collections at the Academy of Natural Sciences, Philadelphia, to study the Clemens types.

Dr. E. D. Ball, accompanied by Dr. A. L. Quaintance, recently visited the boll weevil station at Florence, S. C., being conducted by the Bureau of Entomology in co-operation with Clemson College. A visit was also made to the extensive plant-breeding farms of David R. Coker at Hartsville, S. C.

Mr. H. G. Crawford, Entomological Branch, Ottawa, Can., spent the week of July 10th at Arlington, Mass., consulting with D. J. Caffrey in charge of the European Corn Borer investigations for the United States Bureau. The moths were flying freely at the time of his visit and an excellent opportunity was obtained to view the conditions of the infestation.

Dr. Guy A. K. Marshall, Director of the Imperial Bureau of Entomology, London, accompanied by Dr. E. J. Butler, Director of the Bureau of Botany, spent two days in Ottawa recently. Dr. Marshall and Dr. Butler were enroute to attend the Pan-Pacific conference which is to be held during the month of August in Australia.

Mr. Harry S. Smith, formerly chief of the Bureau of Pest Control, California State Department of Agriculture, has been appointed Associate Professor of Entomology of the University of California, to have charge of beneficial insect investigations, this work having been transferred to the University by the Legislature. He will be stationed at the Citrus Experiment Station at Riverside.

The following resignations from the Bureau of Entomology have been announced; W. W. Porter, sweet potato weevil, Miss.; Guy Hughes, temporary junior entomologist, Baton Rouge, La., to become principal of the Smith-Hughes High School in Louisiana; Messrs. W. V. Reed, I. J. Condit and G. E. Riley, collaboraters, to enter commercial work; R. W. Wells, in charge of the ox-warble laboratory, Middletown N. Y., to engage in business.

Mr. E. J. Newcomer, of the Bureau of Entomology, stationed at Yakima, Washington, has been elected Vice-President of the Northwestern Association of Horticulturists, Entomologists and Plant Pathologists at its sixth annual meeting held at Boise, Idaho, July 23–26.

Professor George A. Dean, Professor of Entomology in the Kansas Agricultural College and Entomologist of the Agricultural Experiment Station, has been appointed Entomologist in charge of Cereal and Forest Insect Investigations, Bureau of Entomology, to assume his duties September 1. Acting on the advice of his physicians, Mr. W. R. Walton found it necessary to give up the heavy work connected with the administration of this office and has taken leave in order to recuperate in health. Professor Dean will devote considerable time this fall to visiting the various field laboratories engaged in cereal and forage insect investigations and will give special attention to corn borer operations, the grasshopper situation, Hessian fly work, etc.

Dr. F. C. Bishopp, in charge of the Dallas, Texas, Laboratory of the Bureau of Entomology, visited Washington on official business, late in June. On July 1 he left for Dallas, but was obliged to leave the train at Columbus, Ohio, and upon the advice of a physician underwent an operation for appendicitis at that place. He has sufficiently recovered to return to Dallas and resume his duties.

On March 1, 1923, Mr. J. C. Hamlin was promoted by the Australian Commonwealth Prickly-Pear Board to control the scientific investigations of that body. On June 23rd, Mr. Hamlin landed at Vancouver enroute to Uvalde, Texas, where he will carry out special work for his Board during the next few months. During Mr. Hamlin's absence from Australia, Mr. W. B. Alexander is Acting Officer-in-Charge of the Board's scientific work.

According to the *Official Record*, arrangements have been completed by which Alexander Znamensky, a Russian entomologist, will be employed by the Bureau of Entomology for a year to conduct investigations in southern Russia to determine whether parasites likely to be useful against the Japanese beetle can be found there and shipped to the infested areas in New Jersey. Species of beetles closely related to the Japanese beetle are known to occur in southern Russia. Mr. Znamensky will be located at Poltava or Stavropol.

Messrs. C. P. Clausen and J. L. King, who have been in Japan seeking parasites of the Japanese beetle, have been heard from since the earthquake. They were away from Yokohama, and are safe. Dr. D. T. Fullaway was also in Japan for a short time, but resigned and returned to Honolulu before the earthquake. Dr. J. F. Illingworth is also in Japan, and has not been heard from, but it is assumed that he was away from the scene of the earthquake on a collecting trip.

Transfers in the Bureau of Entomology have been announced as follows: Dr. A. D. Hopkins, formerly in charge of Forest Insect Investigations, is now to devote all of his time to research in connection with bioclimatics; on July 1, Mr. S. A. Rohwer was transferred from Forest Insect Investigations to the miscellaneous fund for duty in the U. S. National Museum; Perez Simmons and George W. Ellington from Washington, D. C., to Sligo, Md.

Professor J. G. Sanders, formerly Director of the Pennsylvania Bureau of Plant Industry, who refused to submit to heavy reductions in funds for quarantine work on Japanese beetle, potato-wart, European Corn Borer, etc., by a new Secretary of Agriculture wholly unfamiliar with the work, has left the state department and become Manager of the Spray Oil Department of the Sun Oil Company of Philadelphia, manufacturers of their new self-emulsifying spray oil.

According to *Science*, fetes began on August 6 at Millau (Aveyron) in honor of Fabre, the famous French entomologist. A monument, the work of the sculptor Malet, representing Fabre, a magnifying glass in his hand, examining an insect, was unveiled. It was actually at St. Léons that Fabre was born, but St. Léons is a little village of a few hundred inhabitants, and it was thought desirable to erect the statue in the neighboring town of Millau. Fabre is chiefly associated with Serignan, near Orange, for it was here in his garden that he pursued his entomological studies.

It is announced that one of the parasites recently introduced from Europe as an enemy of the European Corn Borer, namely *Exoristus roborator* Fab., has been recovered from the field by the collection of corn borer larvae from which the parasite has been reared. It seems extremely probable, therefore, that this species has succeeded in establishing itself in this country. The recovery of this parasite is recorded from five or six different localities.

Mr. E. G. Smyth of the Bureau of Entomology, has left Guatemala for Mexico, where he will investigate the bean beetle situation in the area between Mexico City and Vera Cruz, with especial attention to the localities in the vicinity of Jalapa and Cordova. This region is at the edge of the Mexican plateau, and it is hoped that any parasites collected in this vicinity will be more easily adapted to the climatic conditions in the southeastern portion of the United States.

In response to a request from the National Park Service, Mr. J. C. Evenden left the Forest Insect Field Station at Coeur d'Alene, Idaho, June 6, to makeanexamination of serious defoliation apparently caused by the spruce budworm in the vicinity of the Tower Falls and Camp Roosevelt section, Yellowstone National Park. On his return Mr. Evenden will make an examination of a Dendroctonus control project near Boise, Idaho, which is being conducted by means of logging, and also an area defoliated by the white pine butterfly. The Dendroctonus control project on the Helena National Forest was completed May 26. Approximately 500 trees were treated.

Mr. J. R. Douglass, formerly connected with the Mexican bean beetle laboratory, Bureau of Entomology, at Birmingham, Ala., has established headquarters at Estancia, N. Mex., for the study of the Mexican bean beetle under western conditions. He reports that the dry conditions which existed during the summer of 1922 and most of last winter are continuing to some extent, and the acreage of beans has been greatly reduced. Apparently the beetles are appearing from hibernation in much smaller numbers than usual—a condition which has also been reported farther south in New Mexico by Dr. Robert Middlebrook. It appears that the dry weather of last summer, together with the cutting-off of their food supply, has influenced this unusual condition.

On June 22 Miss Isabel Cooper, scientific assistant of the Williams Galapagos Expedition, brought to Washington for identification the Heterocera and Hymenoptera secured by this expedition. It is understood that the types of all the new species are to be retained for the National Collection. These collections will be studied by Mr. Schaus and Mr. Rohwer. At the same time Miss Cooper took away several thousand Lepidoptera which had been secured by William Beebe while working at the British Guiana Experiment Station. These specimens had been identified by Mr. Schaus and are being returned to the New York Zoological Society for their collections. The work at the British Guiana Experiment Station and also the work done by the William Galapagos Expedition is carried on under the direction of William Beebe, with headquarters at the New York Zoological Gardens.

On July 25th, about 25 representatives of the Federal Horticultural Board, Bureau of Entomology, and several near-by States, visited the Japanese Beetle Laboratory at Riverton, N. J., and apple and peach orchards in the vicinity. At a conference in the afternoon, C. H. Hadley and L. B. Smith explained the various phases of the

work, and remarks were made by Professors E. N. Cory, State Entomologist of Maryland, and W. J. Schoene, State Entomologist of Virginia. In addition to the laboratory staff, the following were present: Dr. A. L. Quaintance, Bureau of Entomology, Dr. K. F. Kellerman and G. B. Sudworth, Federal Horticultural Board, Washington, D. C.; Professor W. J. Schoene, Blacksburg, Va.; Professor E. N. Cory and C. C. Hamilton, College Park, Md.; Professor Wesley Webb, Dover, Del.; Professor H. E. Hodgkiss, State College, Pa.; Messrs. Frank P. Willits, John M. McKee and W. A. McCubbin, State Department of Agriculture, Harrisburg, Pa.; Dr. T. J. Headlee and H. B. Weiss, New Brunswick, N. J.

Mr. L. S. McLaine of the Entomological Branch, Ottawa, Can., returned on July 23rd from an inspection trip to western Canada. During his absence he visited the new fumigation and inspection building at Vancouver. The new station is of hollow tile construction, covered with cement, and measures fifty by one hundred feet. It contains four fumigation chambers and in addition the large inspection and packing rooms are so constructed that they can readily be used for fumigating grain and other products. Three hundred and fifty tons of grain can be treated at one time. Arrangements were made with the British Columbia authorities in regard to carrying out the new Regulations under the Destructive Insect and Pest Act. The Satin Moth situation was also looked into. The laboratories maintained by the Branch at different points were also visited. The alfalfa weevil scouting work in southern Alberta and the inspection work at Winnepeg were discussed with the officials in charge of these duties.

The following appointments have recently been announced in the Bureau of Entomology: Temporary employees, Boll weevil laboratory, Tallulah, La., Wm. C. Gideon, Jos. Nolan Harvey, Jr., Sterling B. Hendricks, L. P. Hodges, Albert L. Monroe, R. W. Necaise, Sherrill Sevier; tobacco insect laboratory, Clarksville, Tenn., L. N. Judah, Scott C. Lyon, F. C. Plummer, W. B. Weakley; screwworm substation, Uvalde, Tex., Graden Barnett, H. L. Weatherby; Mexican beetle, Birmingham, Ala.; John P. Wemple, junior entomologist, Baton Rouge, La.; temporary, boll weevil force, Florence, S. C.; E. D. Bateman, L. L. Benton, C. A. Bolt, Wm. H. Craven, G. E. Hawkins, M. B. Hoffman, J. H. Hunter, A. K. Inman, M. L. Jones, J. G. Lewis, C. Ling, K. M. Mace, T. G. Martin, M. C. Martin, R. L. Martin, A. L. McCrary, W. D. McGowan, L. G. McGraw, J. L. Nichols, D. L. Outen, S. D. Reid, T. D. Rickenbaker, Wm. J. Roberts, T. S. Smith, R. W. Moreland, J. N. Todd; John Cotton, Robert M. Fouts; Dr. Carroll G. Bull, temporarily, to do serological work in connection with the investigations of malaria mosquitoes.

A conference of entomologists concerned with the European Corn Borer problem was called to meet at the Experiment Station, Wooster, Ohio, June 29, by Director Truax of the State Department of Agriculture. Present at the conference were Director Truax, Director Williams of the Experiment Station, Dr. Herbert Osborn of Ohio State University, R. D. Faxon, chief of the State Bureau of Entomological Inspection and Quarantine; H. A. Gossard, J. S. Houser, L. L. Huber, C. R. Neiswander and C. R. Cutright of the Experiment Station. E. G. Brewer in charge of the Federal quarantine for Ohio and adjacent areas was unavoidably absent, but sent an able assistant in Mr. Fall, who outlined fully the methods and plans of the Federal Service for the coming season. All present participated in the discussion. Special praise was given to the effective clean-up campaign put on in Ashtabula County last

spring by Professor T. H. Parks and County Agent Sleeth. Mr. Huber was able to report gratifying progress at the laboratory in starting off the life-history studies and carrying through in full to date the whole experimental program outlined in the spring. Director Truax read a letter of regret from Governor Donahey that he was unable to be present. The Governor, Director Truax and Director Williams all gave assurance of their support of the work under way.

The Federal Horticultural Board held a conference at the State House, Boston, Mass., on August 17, in regard to the Federal inspection and certification of stock to be shipped out of nurseries within the gipsy moth quarantined area. Some shipments sent into other states during the past season were found infested, most of them emanating from one nursery. The speakers included Federal and State Inspectors, Commissioners of Agriculture and nurserymen. The concensus of opinion was that each nurseryman should be responsible for keeping his own nursery clean and should carry out all methods of treatment necessary to that end: that the State authorities should give inspections and advice and direct clean-up campaigns around the nurseries to aid in the work: and that Federal inspection and certification would be refused at all nurseries not granted a State certificate. The following entomologists were present: Dr. L. O. Howard, Dr. A. L. Quaintance, Dr. C. L. Marlatt, E. D. Ball, Washington, D. C.; Mr. A. F. Burgess, D. M. Rogers, J. N. Summers, C. W. Collins, H. L. Blaisdell and S. S. Crossman of the Federal gipsy moth force; Mr. R. I. Smith and L. M. Scott, Plant Quarantine Inspection Service; W. C. O'Kane, State Entomologist, Durham, N. H.; W. E. Britton, State Entomologist, New Haven, Conn.; A. E. Stene, State Entomologist, Harry Horovitz and R. A. Sheals, Assistant, Providence, R. I.; Mr. H. L. McIntyre, B. D. Van Buren and A. M. McDonald, Conservation Commissioner, Albany, N. Y.; R. H. Allen, Q. S. Lowry, George A. Smith, Dr. A. W. Gilbert, Commissioner, State Department of Agriculture, Boston, Mass.; Dr. Thomas J. Headlee, State Entomologist, New Brunswick, N. J.; Mr. C. H. Hadley, Director, Bureau of Plant Industry, Harrisburg, Pa.; George A. Dean, State Entomologist, Manhattan, Kan.

A party of Ohio Entomologists and other state and county officials visited Port Stanley, Ontario, Canada, September 7–8, to observe the corn borer damage there and to study the control methods being used against this pest by the Canadians. The party was met by the Canadian Entomologists, with whom a joint session was held the evening of September 7th. On the 8th, a field trip was made under the supervision of the Canadian Entomologists. The party crossed Lake Erie on the State Fisheries Boat, Oliver H. Perry. The following entomologists were in the party: Herbert Osborn, Columbus, Ohio, Harrison Garman, Lexington, Ky., Erle G. Brewer, Cleveland, Ohio, C. O. Larrabee, Cleveland, Ohio, T. H. Parks, Columbus, Ohio, P. A. Howell, Cleveland, Ohio, F. W. Poos, Sandusky, Ohio, Raymond C. Osburn, Columbus, Ohio, Frank N. Wallace, Indianapolis, Ind., Geo. N. Dean, Washington, D. C., W. H. Larrimer, Lafayette, Ind., J. S. Houser, Wooster, Ohio, D. M. DeLong, Columbus, Ohio, N. E. Shaw, Columbus, Ohio, Richard Faxon, Columbus, Ohio, L. L. Huber, Geneva, Ohio, C. R. Neiswander, Geneva, Ohio, H. A. Gossard, Wooster, Ohio, D. J. Caffrey, Arlington, Mass., and M. D. Leonard, Albany, New York.

Horticultural Inspection Notes

Mr. George H. Russell, who for the past year has been stationed at New Orleans, Louisiana, has temporarily taken over the work of the Federal Horticultural Board in Galveston. He will later proceed to Del Rio, Texas, to assist in the enforcement of the Board's regulations.

The Federal Horticultural Board will open the port of Astoria, Oregon, for the entry of agricultural products under permit. The work at that port will be in charge of Mr. W. H. Freeman who has had many years' experience in plant quarantine work.

Mr. Harry B. Shaw, Pathologist in Charge of the Office of the Federal Horticultural Board in New York, attended the meeting of Phytopathologists held in Geneva, New York from July 9 to 13.

Messrs. R. D. Kennedy and R. G. Cogswell and J. W. O'Brien, inspectors of the Federal Horticultural Board stationed in New York have discovered six shipments of narcissus bulbs arriving from France slightly infested with larvae of the Lesser Bulb Fly.

Mr. Horace S. Dean, a graduate of the University of Tennessee, was recently appointed Plant Quarantine Inspector with headquarters at Washington, D. C., for the purpose of assisting in the pathological inspection of imported plants and plant products. He will also assist in the sterilization studies now being conducted for the purpose of determining a satisfactory treatment of infected plant material.

Professor R. Kent Beattie, Pathologist in Charge of the Office of Foreign Plant Quarantines, is making his annual inspection, on the west coast, of plants introduced under special permit. A similar inspection is being conducted in the East by Messrs. N. Rex Hunt and J. M. R. Adams.

Mr. Roberts G. Cogswell, who has for the past three years been assisting in the inspection work at the port of New York, was recently transferred to Washington for the purpose of assisting in the examination of plant material.

Mr. Clyde P. Trotter, who is in charge of the Board's activities in Galveston, Texas, recently visited Port Arthur, Beaumont, Orange, Sabine, and Pt. Neches, Texas, to determine the number of foreign ships arriving at those ports and the possibilities of contraband materials arriving on such vessels, either as ship's stores or passengers' baggage.

At the request of Commissioner Harry D. Wilson of the Louisiana State Department of Agriculture and Immigration, a conference to discuss the present camphor scale situation was held in New Orleans on August 6. This conference was attended by state officials of Louisiana, Mississippi, Alabama, and Texas, as well as several representatives of the Bureau of Entomology and the Federal Horticultural Board. Immediately following the conference, the visitors were conducted by representatives of the Bureau of Entomology through the heavily infested portions of Audubon Park to see the work of the camphor scale and the results of experiments in its control.

The port of Detroit was recently visited by Mr. E. R. Sasscer, Entomologist in Charge, Plant Quarantine Inspection Service, Federal Horticultural Board, for the purpose of determining the advisability of placing an inspector at that port to assist the Custom officials in the enforcement of the various quarantines promulgated by

the Board. As a result of this trip, it was evident that the work at that port was not sufficiently important to warrant the placing of an inspector there permanently. Arrangements were made, therefore, with Mr. J. W. Enwright of the Bureau of Entomology to serve as a collaborator of the Board, especially during the bulb shipping season.

On August 5 a passenger arrived at New Orleans from Antwerp, Belgium, having in his baggage ten cotton samples collected from various sections of South Africa, China, and Brazil. The owner proposed to take them to Dallas, Texas and Atlanta, Georgia. Upon examination the samples were found to contain some two hundred and fifty seeds. After a full explanation of the quarantine was made, the passenger willingly consented to the destruction of the entire lot of samples.

On August 28, Mr. Ivan Shiller, an inspector of the Federal Horticultural Board located in New York, discovered that the S. S. Ponce, arriving from Porto Rico, contained 1650 bags of cotton seed for trans-shipment and export to Glasgow, Scotland. Upon examination, this seed was found to be infested with the larvae and pupae of the Pink Bollworm. Mr. Shiller supervised the unloading of the seed and the cleaning of the hold of the vessel.

Mr. L. R. Dorland, the inspector in charge of the work of the Federal Horticultural Board at Nogales, Arizona, recently visited Douglas and Naco, Arizona for the purpose of conferring with Custom and railroad officials. Incidentally, while at these ports he secured figures on the amount of foreign business conducted at those ports, and information concerning the danger of introducing plant pests in commodities arriving from Mexico.

A large amount of Italian broom corn is entering Canada through the port of Boston where it is being treated for the European Corn Borer. The work of this pest is very evident in many shipments but no living larvae have been discovered by Canadian inspectors.

Inspectors Beaulne and Cameron in Montreal, and Ryan and Gibson in Toronto, have been examining cars of Jamaica bananas, which were transhipped at Philadelphia on account of the danger of their being infested with Japanese Beetle. Large flights of this insect were reported as occurring around the docks at the time the Jamaica boat was unloading.

Apicultural Notes

The annual picnic of the Allegheny County Beekeeper's Association of Pennsylvania was scheduled to be held at West End Park, Pittsburgh, Pa., Saturday, September 8. The Secretary is Mr. A. T. Keil, Glenfield, Pa.

The annual meeting of the Alabama Beekeeper's Association was scheduled to take place in the Chamber of Commerce Auditorium, Montgomery, Ala., on Friday September 13. Mr. M. C. Berry, Hayneville, Ala., is Secretary of this Association.

A mass meeting for Ohio beekeepers was held in the Horticultural Building at the Ohio State Fair, Columbus, Ohio, on Friday, August 31. The problems connected with the eradication of American foul brood in Ohio were discussed.

Dr. A. P. Sturtevant, Apicultural Assistant in charge of Bee Disease Investigations, of the Bee Culture Laboratory of the Bureau of Entomology, has resigned to accept the position of Assistant Professor of Bacteriology at the New York Homeopathic Medical College, New York City.

Mr. Martin H. Cassidy, instructor in beekeeping at the Massachusetts Agricultural College, Amherst, Mass., and Mr. S. H. White, one of his students, attended the Wisconsin Beekeeper's Chautauqua and the dedication of the Miller Memorial Library at Madison, Wis., August 13–16. They made the trip by automobile, and returned via Medina, Ohio, visiting the apiaries and factory of the A. I. Root Company.

The Miller Memorial Library of Beekeeping was dedicated and formally turned over to the University of Wisconsin on the morning of August 17. Mr. C. P. Dadant, chairman of the Committee made the presentation address. President E. A. Birge on behalf of the University, made the address of acceptance. Other addresses were made by Mr. E. R. Root, Dr. E. F. Phillips and Mr. B. F. Kindig of the Committee, and Mr. N. E. France. This occurred at one of the most important and best attended beekeepers' conferences ever held. About one thousand volumes are already in the library and an endowment for it is being created by beekeepers who have profited by the teachings of Doctor Miller. Books and magazines are being contributed to the library by European and American beekeepers.

The members of the Maryland State Beekeeper's Association visited the Bee Culture Laboratory of the Bureau of Entomology, Washington, D. C., on July 28. Rain prevented any outdoor demonstrations, but a goodly sized crowd gathered to hear the program given by the laboratory staff. The following papers were presented: "Hourly Weight Changes of a Scale Colony" by J. I. Hambleton; "Studies of a Colony in an Observation Hive" by Bruce Lineburg; "American Foul Brood" by A. P. Sturtevant; "Language of the Bees" by Archie Shaftesbury; "A Brood-Rearing Curve" by W. J. Nolan; "Moulting of Larvae" by L. M. Bertholf; "Color of Honey" by Bernard Kurrelmeyer.

Notes on Medical Entomology

The City of Fredericton, N. B., has been carrying on a mosquito control campaign under the direction of Dr. J. D. Tothill. The spring floods left an unusual number of breeding pools in the Fredericton district and very satisfactory results were obtained through oiling.

Dr. L. O. Howard has recently published an article entitled "A Fifty-Year Sketch-History of Medical Entomology" in the Annual Report of the Smithsonian Institution for 1921, pages 565–586, 10 plates. The plates are portraits of Sir Patrick Manson, Sir Ronald Ross and Doctors A. Laveran, G. B. Grassi, A. Celli, Carlos J. Finlay, Walter Reed, J. C. Carroll, J. W. Lazear, and Howard T. Ricketts.

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Proceedings of the Eighth Annual Meeting of the Pacific Slope Branch of the American Association of Economic Entomologists

The eighth annual meeting of the Pacific Slope Branch of the American Association of Economic Entomologists was held in the Y. M. C. A. Hut, University of Southern California, Los Angeles, California, September 17 19, 1923.

The meetings were called to order at 2:30 P. M. by Acting Chairman Roy E. Campbell in the absence of H. J. Quayle. A brief business meeting was held at the opening session, followed by several papers. The symposium idea was largely followed in the discussion of the topics and visits were made to the Nicotine Dust Factory of the California Sprayer Co., Los Angeles; the State Insectary at Whittier; and the Liquid Cyanide Plant at Azusa. One session, Wednesday afternoon, September 19, was a joint meeting with the Pacific Division of the Plant Physiological Section of the Botanical Society of America, the Pacific Division of the American Phytopathological Society, and the Ecological Society of America. The meetings closed with a very enjoyable banquet held at the University Club at Los Angeles, where the chairman, R. E. Campbell, acted as toastmaster.

The largest attendance of any of the western meetings was registered, including the following members and visitors:

A. J. Basinger, Riverside, Cal.
R. Kent Beattie, Washington, D. C.
A. E. Bottel, Riverside, Cal.
J. S. Boyce, Portland, Ore.
A. A. Brock, Santa Paula, Cal.
H. E. Burke, Palo Alto, Cal.
R. E. Campbell, Alhambra, Cal.
Eubanks Carsner, Riverside, Cal.
F. R. Cole, Redlands, Cal.
H. Compere, Whittier, Cal.
J. P. Coy, San Bernardino, Cal.
Clifford T. Dodds, Santa Paula, Cal.
E. O. Essig, Berkeley, Cal.
C. K. Fisher, Alhambra, Cal.
W. E. Fisher, Alhambra, Cal.
S. E. Flanders, Saticoy, Cal.
A. J. Flebut, Lindsay, Cal.
F. H. Gates, Santa Paula, Cal.
R. D. Hartman, Palo Alto, Cal.
Frank B. Herbert, Los Gatos, Cal.

W. B. Herms, Berkeley, Cal.
J. F. Lamiman, Berkeley, Cal.
A. O. Larson, Alhambra, Cal.
Arthur C. Mason, Lindsay, Cal.
A. W. Morrill, Los Angeles, Cal.
L. S. Neville, Los Angeles, Cal.
E. R. deOng, Berkeley, Cal.
E. M. Packard, Sacramento, Cal.
D. D. Penny, Pomona, Cal.
M. E. Phillips, Fresno, Cal.
G. P. Rixford, San Francisco, Cal.
Fred P. Roullard, Fresno, Cal.
M. B. Rounds, Azusa, Cal.
H. T. Ryan, Los Angeles, Cal.
E. A. Schwing, Spreckels, Cal.
Henry H. P. Severin, Berkeley, Cal.
H. S. Smith, Riverside, Cal.
L. B. Soliman, Berkeley, Cal.
C. F. Stahl, Riverside, Cal.
H. E. Summers, Los Angeles, Cal.
W. B. Turner, Sacramento, Cal.
Theodore D. Urbans, Sacramento, Cal.
W. H. Volck, Watsonville, Cal.
Geo. P. Weldon, Ontario, Cal.
R. S. Woglum, Los Angeles, Cal.
K. L. Wolff, Los Angeles, Cal.
H. E. Woodworth, Berkeley, Cal.
W. S. Wright, San Diego, Cal.
F. H. Wymere, Berkeley, Cal.

PART I. BUSINESS SESSION

The business meeting was called to order by Acting Chairman R. E. Campbell at 2:30 P. M.

The first order of business was the report of the Secretary-Treasurer which was as follows:

REPORT OF THE SECRETARY-TREASURER
FINANCIAL STATEMENT

1923				
February 1.	On hand			$24.60
(1) March 29	Paid affiliation fee to Amer. Assn. Adv. Sci		$5.00	
(2) April 18	Paid for notices to members to Armstrong School		6.10	
	Stamped envelopes	$2.55		
	1 stencil	.20		
	24 lines @$.03	.72		
	125 copies	1.15		
	Addressing	.63		
	Stamping, folding, sealing	.85		
		$6.10		
(3) August 23	Paid for notices to members to Armstrong School		$4.70	
	110 stamped envelopes	$1.40		
	25 lines @$.05	1.25		
	Running 120 copies	1.00		
	Addressing and mailing	1.05		
		$4.70		
August 23	Total disbursements		$15.80	$24.60
August 23	Amount on hand			$8.80
March 29	Received interest			.52
August 23	Received interest			.44
September 1	On hand			9.76
September 1	Refund due from Amer. Assn. Econ. Ent		$15.80	

The following committees were then appointed by the Chairman:

Affiliation: W. B. Herms, Chairman, E. P. Van Duzee.

Nomination: E. O. Essig, Chairman, H. E. Burke, C. F. Stahl.

Auditing: H. E. Woodworth, Chairman, D. D. Penny.

Resolutions: E. M. Packard, Chairman, Henry H. P. Severin.

Membership: H. E. Burke, three years; C. W. Creel, two years; E. C. Van Dyke, one year.

It was then proposed that the office of Vice-chairman be included among the new nominations. Upon motion, this was duly carried.

The question of membership then followed concerning associate and active standings, there being considerable opposition to the associate standing because so many were never moved up into active membership as they should be.

The matter of publishing papers was then presented and discussions brought out the many difficulties that members experience in trying to get their papers published in the official journal of the society. The discussion resulted in a motion by H. S. Smith "that it be the sense of the meeting that the JOURNAL OF ECONOMIC ENTOMOLOGY be changed to a monthly and the subscription price made according." The motion was seconded by H. E. Burke and carried unanimously. The matter was then referred to the resolutions committee.

The meeting was adjourned for 15 minutes to allow the committees to formulate their reports and called to order at 4 P. M. by the chair. The reports of the committees were as follows:

NOMINATIONS

For Chairman, H. S. Smith, Riverside, Cal.

For Vice-Chairman, C. M. Packard, Sacramento, Cal.

For Secretary-Treasurer, R. E. Campbell, Alhambra, Cal.

Upon motion duly seconded the secretary was instructed to cast the ballot for the election of the nominees. Carried.

The auditing committee reported the accounts in accordance with the statement of the treasurer.

The resolutions committee offered two resolutions as follows:

Resolved: That it is the sense of this meeting that the increase in volume of publication warrants an increase in the capacity of the Journal of Economic Entomology by changing it to a monthly, and that any increased expense involved be met by increasing the subscription price.

Resolved: That a vote of thanks be extended to the University of Southern California for their hospitality in providing the Pacific Slope Branch of the American Association of Economic Entomologists with a meeting place and that the secretary forward a copy of this resolution to the University.

Both resolutions were adopted upon motions duly made, seconded and carried.

PART II. PAPERS AND DISCUSSIONS

Afternoon Session, September 17, 1923

Following the adjournment of the business session Chairman R. E. Campbell opened the regular session and called for the first paper. It was presented by Mr. Stahl as follows:

A DISCUSSION OF *EUTETTIX TENELLA* BAKER AS A CARRIER OF CURLY-TOP OF SUGAR BEETS

By C. F. Stahl, *Assistant Entomologist, Bureau of Entomology*, and Eubanks Carsner, *Pathologist, Bureau of Plant Industry.*

Abstract

Eutettix tenella when feeding, has the ability under certain conditions to produce a systemic disease, known as curly-top in the sugar beet. This ability is acquired by the insect after emerging from the egg as a result of feeding for only a short period upon a plant already diseased. After this feeding some time must elapse before the insect is able to transmit the virus to a healthy plant. This fact indicates that there may be a short incubation period for the virus in the insect. When once the ability to produce the disease is acquired there is no evidence to indicate that it is ever lost during the life of the insect. Although many insects of species other than *Eutettix tenella* have been experimented with, not one has been found that is able to transmit the virus of curly-top.

Since the announcement by Dr. E. D. Ball in 1906[1] that the beet leafhopper (*Eutettix tenella* Baker) was responsible for the disease of sugar beets known as curly-top, the problem has been the subject of practically continuous investigation. As a result of these studies, many interesting and important data concerning the relation of the insect to the disease have been obtained and reported, but up to the present time the nature of the causative agent has not been learned.

Many of the ascertained points concerning the insect and its function in transmitting the disease are suggestive and as they may be of assistance in future work conducted for the purpose of determining the causative agent for the disease, it is deemed desirable to bring together in a brief discussion some of the more important facts relating to this phase of the problem.

This jassid which inhabits the arid and semi-arid regions of the West, shows some preference for plants of the family Chenopodiaceae, and produces under certain conditions in the sugar beet a systemic disease, curly-top. Available evidence indicates that curly-top has been present in sugar beet fields in the districts inhabited by this insect from the time the beets were first planted there. This crop appears to have been selected by the insect because the plants are suitable for oviposition and food.

The ability to transmit curly-top is acquired by the insect after it has

[1]16th Ann. Rept. Agr. Coll. Utah Exp. Sta. for 1905, p. XVI.

emerged from the egg; this has been demonstrated experimentally in the laboratory as well as by field observations. Nymphs which were removed immediately after hatching from diseased plants and before they had fed on them, were placed on healthy plants and in no case were they able to produce the disease. After feeding on an infected plant, however, they were able to transmit the disorder. Important additional evidence bearing on this phase has been obtained in the field. It is often possible to find in cultivated areas and in beet fields in the spring large numbers of adults of this insect which will not produce the disease. Fields heavily infested by this jassid have been noted in which the disease was either absent or present only in scattered cases. These facts suggest strongly that the leafhopper is normally unable to produce the malady and that there must be a source, continuous from year to year, from which the virus can be obtained.

No evidence has yet been gained to support a theory that this acquired ability is of any advantage to the insect.

When a nonviriferous insect, i. e., one which does not carry the virus, is allowed to feed upon a plant affected with curly-top, in our experiments it invariably becomes able to transmit the disease to healthy plants. The length of the feeding period required for the insect to obtain the virus is evidently very short. Reports regarding this point vary, intervals as short as one or two minutes having been indicated as sufficient in some instances. The writers have produced curly-top in healthy plants with insects which had fed on diseased plants for 10 minutes only.

After feeding, a short interval apparently must elapse before the virus can be transmitted to a healthy plant and produce disease, four to six hours under high temperatures having been reported. The writers have been able to secure such a transmission of the disease by means of *Eutettix tenella* within a period of 15 hours after the insect had fed on a diseased beet plant. It has been noted that at least for a certain period, a higher percentage of insects is able to produce the disease as the length of the interval between feeding and inoculation increases. The increase in number is greatest during the interval between 24 and 72 hours. The evidence available at the present time, therefore, indicates that the transmission is not mechanical, that is, simply by the contamination of the mouthparts.

When the insect is able to transmit the virus of curly-top, only a short feeding period on the healthy plant is necessary. A period of 5 minutes has been reported as sufficient for transmission but the minimum

period noted by the writers has been 20 minute for sugar beets and 10 minutes for chickweed (*Stellaria media*). This indicates that only a small amount of virus may produce a typical case of curly-top. It has been reported that the larger the number of leafhoppers feeding on a plant, the more rapid the development of the disease. This statement is contrary to the experience of the writers who have demonstrated many times that a single individual of this species, either nymph or adult, will not only produce as serious a case of curly-top as will a large number on a single plant, but also there is no difference in the rate of development of the disease.

When once the insect is able to produce the disease, this ability is apparently never lost. Evidence to support this statement has been obtained by keeping individuals known to be viriferous on plants from which the virus has never been obtained and determining from time to time whether or not they were capable of producing the disease. In view of this finding, it is probable that hibernating adults might retain the ability of the virus transmission throughout the winter. This point, however, has not been tested by the writers. It is also known that nymphs do not lose the disease-producing ability during the molting process. There is apparently no evidence to support the theory that the nymph is more virulent than the adult.

An interesting fact encountered in the problem is the apparent inability of any species other than *Eutettix tenella* to transmit the disease. Although this possibility has been assumed for a number of years, little mention has been made of it in the literature. The writers have tested several species of insects from time to time and during the past season tests have been conducted with species commonly collected on sugar beets and related plants. In all cases the insects were forced to feed for some time on beets badly affected with curly-top. From these diseased plants they were transferred to young healthy beet plants growing under conditions especially favorable for the development of the disease. From one to five individuals were confined on a plant. These tests are still in progress but thus far all results have been negative.

The following is a partial list of the species tested:

Species Tested	No. tested
Cicadula sexnotata Fall	17
Lygus pratensis L	12
Nysius sp	10
Systena taeniata Say	6
Eutettix strobi Fitch	6
Thamnotettix montanus Van D	5
Thamnotettix geminatus Van D	6

Empoasca sp.	60
Agallia spp.	71

Undetermined aphids found on diseased beets have been transferred to healthy plants on many occasions but without producing the disease. If, as now appears, no species of insect other than *Eutettix tenella* can transmit curly-top, some explanation of the peculiar adaptation in this case should be sought by further investigation.

The paper was then discussed by Mr. E. Carsner, H. H. P. Severin, C. F. Stahl and other members.

Chairman R. E. CAMPBELL then called for the next paper on the program.

INVESTIGATIONS OF BEET LEAFHOPPER (*EUTETTIX TENELLA* BAKER) IN SALINAS VALLEY OF CALIFORNIA

By HENRY H. P. SEVERIN, Ph.D., *California Agricultural Experiment Station.*

ABSTRACT

The multiplication of the beet leafhopper (*Eutettix tenella* Baker) in the Salinas Valley occurs chiefly on sugar beets. The nymphs were bred from eggs deposited in seventeen weeds growing in the cultivated areas. There was no evidence to show that a migration occurs from the San Joaquin into the Salinas Valley through the Coalinga-King City mountain pass. During the autumn dispersal the overwintering adults fly to the foothills, following the Salinas River and its tributaries.

Early planting of sugar beets (December to February) is the only known practical method of preventing losses from curly leaf in localities outside of the fog belt. In the fog belt districts late planted beets make a better tonnage than early plantings in a normal season of rainfall. Planting should be discontinued from March 1, until after the spring dispersal. The limit of beet growing in the fog belt as far as curly leaf is concerned varies from 20 to 30 miles in California.

I. LOCATION AND BOUNDARIES

The Salinas Valley is the largest of the many valleys inclosed within the Coast Range in California. From Monterey Bay it extends in a southeasterly direction, in a line parallel with the coast, to its head—a distance of about 100 miles. Its average width is from 7 to 9 miles. Upon the northwest the valley is bounded by Monterey Bay; upon its sides by the Sierra Santa Lucia and Sierra Salinas ranges, with their outlying spurs upon the west; and by the Gabilan and Mount Diablo ranges upon the east, the latter separating the Salinas Valley from the San Joaquin Valley of the interior of the State.

II. INTRODUCTION

Ball (1) believes that the beet leafhopper migrates from the San Joaquin into the Salinas Valley. He found the leafhoppers "breeding in abundance on the native Atriplex in the Tulare region. This district

extends down as far as Bakersfield . . . . In the Salinas Valley, King City is the nearest beet growing point to this region, and is in direct line of air drainage between Monterey Bay and the low pass over into the interior."

According to Ball (1) "curly leaf rarely appears in the region along the coast, where fogs are prevalent, but as one passes to the interior points it becomes more frequent and seems to be somewhat proportional to the temperature encountered . . . . Except in periods of abundance the beet leafhopper is not found in the region along the coast from San Francisco south to the Mexican border."

III. Favorable Breeding Plants in Cultivated Areas

In the Salinas Valley annual saltbushes are scarce and the multiplication of the pest occurs chiefly on sugar beets. The beet leafhopper has been bred from the following plants growing in the cultivated areas of the valley:

Plants in Which Beet Leafhopper Deposited Eggs in Cultivated Areas of Salinas Valley.

Chenopodiaceae.

Annual Saltbushes.

1. Silverscale or Fog Weed (*Atriplex argentea*). Native.
2. Bractscale (*Atriplex bracteosa*). Native.
3. Redscale or Red Orache (*Atriplex rosea*). Introduced from Europe.

Perennial Saltbushes.

4. Australian Saltbush (*Atriplex semibaccata*). Introduced from Australia.

Pigweeds.

5. Pigweed or Lamb's Quarters (*Chenopodium album*). Common European weed.
6. Nettle Leaf Goosefoot (*Chenopodium murale*). Naturalized from Europe.

Weeds.

7. Russian Thistle (*Salsola kali tenuifolia*). Introduced from Asia.

Plants From Other Families

8. Curly Dock (*Rumex crispus*). Naturalized from Europe.
9. Rough Pigweed (*Amaranthus retroflexus*). Introduced from tropical America.
10. Tumble Weed (*Amaranthus graecizans*). Naturalized from tropical America.
11. *Amaranthus deflexus*. Introduced from southern Europe.
12. Wild Radish (*Raphanus sativus*). Naturalized from Europe.
13. Chinese Pusley (*Heliotropium curassavicum*). Widely distributed in the East and in South America and the Old World.
14. Common Horehound (*Marrubium vulgare*). Naturalized from Europe.
15. Tolguacha or Jimson Weed (*Datura meteloides*). Texas to California and adjacent Mexico.
16. Black Nightshade (*Solanum nigrum douglasii*). Native of Europe.
17. Spiny Clothbur (*Xanthium spinosum*). Native of Europe? Naturalized from Tropical America? Introduced from Chili?

IV. Spring Dispersal

During the period 1918–1923, investigations in the Gabilan and Mount Diablo ranges conducted by Mr. W. W. Thomas, Mr. E. A. Schwing and the writer, have failed to show any evidence, whatsoever, that a

migration of the beet leafhopper occurs from the San Joaquin Valley into the Salinas Valley through the Coalinga-King City mountain pass. There was no evidence to show that an enormous congregation of the insects occurs on the east side of this mountain pass during the spring. Wherever annual saltbushes grow in the mountain passes along roadsides, or covering alkali sinks, leafhoppers may be taken, which congregated on these plants after the pasture vegetation became dry on the foothills. The general distribution of the hoppers on annual Atriplexes in the mountain passes indicates that these insects have a keen sense of smell. Those leafhoppers which assemble on favorable food and breeding plants during the spring flights remain in the cultivated foothill regions together with the later summer generations.

During the period 1918–1921, the first appearance of the pale green spring brood adults in the cultivated areas of the Salinas and San Joaquin Valley occurred as follows:

SALINAS VALLEY	SAN JOAQUIN VALLEY
1918 May 8, King City	1918 April 24, upper.
1919 April 22, King City	1919 April 8, 14, 28, upper, middle, lower.
1920 April 22 or 23, King City	1920 April 23, upper.
1921 April 25 to 30, King City	1921 April 6, 14, upper, middle.

V. AUTUMN DISPERSAL

During 1918, the first indication of an autumn dispersal of the dark overwintering adults occurred on October 11 to 13, in a mountain pass at Bitterwater about 15 miles northeast of King City. The insects had left the dried Redscale or Red Orache but some of the hoppers were still present on partly green Silverscale or Fog Weed growing in a large alkali sink. A congregation of adults had occurred on green pasture vegetation growing at the base of the foothills adjacent to the alkali sink. The movement of the dark overwintering adults from the alkali sink was not toward the San Joaquin Valley but in the opposite direction.

During the autumn dispersal in the Salinas Valley the dark overwintering adults were rarely taken on Red Stem Filaree (*Erodium cicutarium*) growing on the foothills within the fog belt. The leafhoppers, however, were captured more abundantly outside of the fog belt between Greenfield and King City and were far more numerous on the northeastern than on the southwestern foothills of the Gabilan and Sierra Santa Lucia ranges respectively.

During the autumn of 1919, large numbers of dark overwintering adults disappeared from the experimental field at King City on November 21. After the beets are topped large numbers of nymphs probably succumb in a dry autumn unless they are able to obtain food from

green plants growing along irrigation and drainage canals and roadsides.

During October and November 1920, Mr. E. A. Schwing discovered the dark overwintering adults on perennials growing along the Salinas River and its tributaries flowing from the Coast Range. As soon as the pasture vegetation germinated most of the leafhoppers left the perennials and were found on Red Stem Filaree growing on the foothills.

During the autumn of 1921, Schwing and the writer again found the dark overwintering adults commonly on perennials growing along the stream-ways of the Salinas River and its tributaries. In the fog belt leafhoppers were rarely taken on perennials but in the interior specimens were commonly captured on Creek Senecio (*Senecio douglasii*) and *Lepidospartum squamatum*. During the morning the bugs were sluggish and inactive and some were found below the bushes on the sand among the roots, fallen twigs and leaves. At sunset a few specimens were attracted to the wind-shield of the automobile and mating was observed. Wherever the two species of perennials were swept with an insect-net from the entrance to about 10 miles up some of the canyons, the hoppers were obtained.

VI. Curly Leaf

After the autumn dispersal of the dark overwintering adults to the foothills has occurred, the cultivated areas are not entirely free from beet leafhoppers during the winter, and these stragglers when abundant are a serious menace to early planted sugar beets. During 1918, heavy September rains fell in the Salinas Valley germinating the seeds of the pasture vegetation on the foothills and a new growth of vegetation developed in the cultivated regions. During November and December, nymphs were taken on vegetation growing along roadsides adjacent to fields in which beets had been harvested. Nymphs which hatched from eggs deposited by the summer brood adults in Red Stem Filaree were also taken on the foothills at King City. These nymphs acquired the winged stage after the autumn flights had occurred and the adults invaded the early planted beet fields adjacent to the foothills. In the upper Salinas Valley over one-half of the crop showed curly leaf symptoms before the spring brood flew into the beet fields on April 22 or 23, 1919. During a dry autumn when annual plants are mostly dry along roadsides, the number of nymphs can be greatly reduced by removing green vegetation along irrigation and drainage canals in beet fields.

VII. Early Planting of Sugar Beets Outside of Fog Belt

Early planting of sugar beets is the only known practical method of

preventing serious losses from curly leaf in localities outside of the fog belt. The fact that the adults leave the cultivated areas in the autumn has an important bearing with reference to the time of planting beets. In a dry autumn it is necessary to pre-irrigate the soil. In the Salinas Valley the adobe soil becomes very sticky when wet, and it is practically impossible to work the soil after the rainy season begins. Beets should not be planted until the end of November outside of the fog belt between Soledad and King City.

VIII. Fog Belt

Ball (1) in discussing the time of appearance of swarms of beet leafhoppers states that flights have occurred in the Salinas Valley "at different seasons and apparently in some instances at different times in the same season." During the past six years large numbers of spring brood adults invaded the fog belt of the Salinas Valley during 1919, 1921 and 1922. The leafhoppers were distributed in all beet districts of the valley on the dates given under spring dispersal. The spring invasion of the first brood into the fog belt probably depends upon the absence of fog at dusk when the flights occur. During 1918, 1920 and 1923, the fog belt was not entirely free from leafhoppers, although greatly reduced in numbers.

IX. Late Planting of Sugar Beets in Fog Belt

According to Schwing and Hartung (2), "in the fog belt districts more leafhoppers were present and a higher percentage of curly leaf occurred in early planted beet fields than in fields planted after the invasion of the pest had occurred in the Salinas Valley." At Santa Rita, about eight miles from the Pacific Ocean, 60 per cent of the early planted beets were blighted compared with 3 per cent in an area replanted on account of the disease in the same field. March plantings showed 80 per cent curly leaf on July 23, near Chualar, about 20 miles from the ocean, while beet seeds which germinated after May 1, showed only 3 per cent blight on August 5. The same condition occurred in the San Juan Valley; where, on one side of the river, March and April plantings were destroyed by curly leaf; while, on the opposite side of the river, late plantings produced a good crop.

It is evident that the date of planting has been the cause of curly leaf trouble in the fog belt of the Salinas Valley. Planting should be discontinued from March 1, until after the spring dispersal from Gonzales to Monterey Bay. In the fog belt from Chualar to Monterey Bay the soil is usually too wet and the weather too cold and foggy to plant early.

A few quotations from Ball (1) with reference to the absence of curly leaf in late plantings in the fog belt in connection with past outbreaks of the beet leafhopper corroborate the same fact observed in 1921. In 1906, "a planting made late in May did not blight while others did . . . . ." In 1906, "plantings made May 22 and 31, at Soledad and June 3, at Spreckles did not show much blight while all earlier ones in these localities did."

The question has repeatedly been asked, why is it that late planted beets made a better tonnage than early plantings in the fog belt. The answer to this question involves the proper interpretation of some of the facts concerning the life history of the beet leafhopper. In the fog belt of the Salinas Valley, Stahl's (3) "experiments conducted at Spreckels, California, demonstrated that there were unquestionably two generations annually in that locality." When the pale green spring brood adults invade the cultivated areas, most of the specimens were found to be females. There are no flights associated with mating in the beet fields as the pairing of the sexes occurs on the foothills where most of the males remain and die. In the beet fields the females at the egg-laying stage make short flights for the purpose of disseminating the eggs. It is these females of the first generation and the nymphs of the second brood which cause a high percentage of curly leaf in March and April plantings in the fog belt.

Investigations conducted in the fog belt of San Luis Obispo, Santa Barbara, Ventura, Los Angeles and Orange counties, showed that the second brood was greatly reduced in numbers when compared with the first generation. During the serious 1919 outbreak of the beet leafhopper a letter dated September 10, was received stating that swarms of hoppers were flying from beets when disturbed by the beet puller and another report that the horses became covered with leafhoppers during the harvesting of the crop in the fog belt of San Luis Obispo and Santa Barbara counties. These reports were not exaggerated but the leafhopper proved to be *Empoasca viridescens*. A week was spent in estimating the percentages of curly leaf in all of the beet fields and from 6 to 92 per cent of the beets showed curly leaf symptoms. The beet leafhopper was extremely scarce, however, in fact, in most of the fields within the fog belt it was impossible to find a single specimen. The percentage of curly leaf was entirely out of proportion to the number of *E. tenella* present on September 19 to 25. It was found in the fog belt of these two counties that the adults had succumbed to a fungus disease. An examination of the lower surface of the leaves of a single sugar beet

showed 178 dead Jassids, including the beet leafhopper, which had died as a result of a fungus disease. In regions outside of the fog belt, however, no dead fungus diseased insects were found, and near Los Alomos, nymphs and adults were abundant in the badly blighted beet fields.

In the Salinas Valley, no dead fungus diseased leafhoppers have been found in the fog belt and there are other factors which reduce the numbers of the second generation. The summer brood hoppers, however, gradually increase in numbers toward Gonzales, situated near the limit of the fog belt. In Berkeley it was frequently observed that nymphs upon hatching out-of-doors in cages failed to extricate themselves from the eggs and died in a day or two. A high mortality of the nymphs occurs in the fog belt of California, depending upon the distance from the ocean. The nymphs of the second brood do not acquire the winged stage until autumn. Movements associated with mating of the second generation occur at a time when the beets are large enough to withstand the attacks of the leafhoppers. Such factors as a late developing second brood and this generation greatly reduced in numbers, make it possible to grow a crop of beets in the fog belt of the Salinas Valley when planting is delayed until after the spring dispersal of the beet leafhoppers has occurred. The limit of beet growing in the fog belt as far as curly leaf is concerned varies from 20 to 30 miles in California.

X. Bibliography

1. Ball, E. D., 1917. The Beet Leafhopper and the Curly Leaf Disease that It Transmits. Utah Agr. Exp. Sta., Bul. 155, pp. 1–56.
2. Schwing, E. A. and Hartung, W. J., 1922. Utilization of Systematic Observations on Beet Leafhopper (*Eutettix tenella* Baker) and Curly Leaf of Sugar Beets. Jour. Econ. Ent. XV, No. 5, pp. 365–368.
3. Stahl, C. F., 1920. Studies on the Life History and Habits of the Beet Leafhopper. Jour. Agr. Res. XX, No. 4, pp. 245–252.

The papers were fully discussed by the author, C. F. Stahl, E. Carsner and many of the members.

Following announcements concerning the excursion on Tuesday afternoon and the banquet on Wednesday night, the chairman adjourned the meeting until the following morning.

Morning Session, September 18, 1923

The meeting was called to order by Acting chairman R. E. Campbell who announced that because of the serious fire in Berkeley many of the Berkeley delegates, including the secretary, had returned to Berkeley on the night train.

Mr. A. O. Larson was elected temporary secretary and furnished the following reports.

Chairman R. E. CAMPBELL announced that there would be a dinner for the members and an excursion to the plants of the California Sprayer Co., Los Angeles, and the American Cyanamid Co. at Azusa, and also to the State Insectary at Whittier.

Chairman R. E. CAMPBELL: We will now take up the regular program of the day, beginning with the symposium on dusting. The first paper is by Mr. E. R. deOng who has returned to Berkeley. It will be read by Mr. J. F. Lamiman.

THE RELATION BETWEEN THE VOLATILITY AND TOXICITY OF NICOTINE IN SPRAYS AND DUSTS

By E. R. DEONG, *University of California*

ABSTRACT

Free nicotine is very volatile, while nicotine sulfate is nonvolatile. The toxicity of nicotine solutions varies in proportion to their conversion from the salt form to the free alkaloid. The volatilization curve of nicotine is almost an exact parallel of the curve of toxicity both of fumigation and spraying. Dust carriers follow this same law, i. e., an inert material does not free the nicotine as does an active carrier and, hence, is less efficient.

The efficiency of nicotine sulfate sprays frequently shows marked variation especially when combined with different types of spreaders. We now know that the alkalinity of the water used as a carrier has a great influence on the value of the spray. Such differences must be even more marked when dust carriers are substituted for water, because of the extreme variability of the chemical nature and the physical action of the dusts used as carriers.

Nicotine in the free state (levorotatory) is readily volatilized and is much more toxic in this stage than when combined with acids (dextrorotatory) to form non-volatile salts. Hence, the commercial forms of nicotine sulfate are much less toxic than when the alkaloid is freed from the combining acid. Death from nicotine poisoning is the result of a fumigating action, the curve of which is very close to that from spraying as will be shown later. This is in harmony with the work of McIndoo, Thatcher and others and goes to prove that nicotine is a tracheal or "respiratory" insecticide rather than a true contact spray. Exceptions to this are found in the treatment of caterpillars where nicotine may be ingested by the mouth.

Commercial applications of the less toxic form of nicotine sulfate are usually made on the assumption, providing any thought is given to it at all, that the water used as a carrier was sufficiently alkaline to free

the nicotine from the combining acid. The addition of soap, ostensibly as a spreader, has a double value for besides its film-forming value, it increases the alkalinity of the solution. In our experimental work, however, it was found that tap water, slightly above the average of hardness and requiring 1.3 cc. of n/50 sulfuric acid to neutralize 100 cc., did not give the fullest toxicity possible even with the addition of soap. An increase in efficiency of from twenty to forty percent occurred in solutions where sufficient alkali was added over those which were neutral. Such results were secured both in spraying and fumigating and in volatilizing experiments.

Experimental

Nicotine solutions, made with free nicotine and with nicotine sulfate with varying degrees of alkalinity and in tap water, were compared in three ways: (1) Rate of volatilization as a film on leaf surfaces and from solutions, (2) Efficiency as a spray on aphids, (3) Efficiency as a fumigant on aphids.

Volatilization Experiments. The nicotine solutions used in this as well as in the spraying and fumigating experiments were, with the

Table I. Foliage Tests of the Volatility of Nicotine in Various Alkaline Solutions and Under Contrasting Meteorological Conditions

A. Laboratory Tests in clear weather.
B. Laboratory Tests in cloudy, rainy weather.
Series (1) Nicotine residue determined after three hours.
Series (2) Nicotine residue determined after twenty-four hours.
Series (3) Nicotine residue determined after forty-eight hours.

A Clear weather

No.	Type of Solution	*Percent of Nicotine Recovered* Ser. (1)	Ser. (2)	Ser. (3)
1	Nicotine sulfate, no alkali	48.5	29.9	trace
2	Nicotine sulfate+.25 cc. n/1 NaOH	50.0	25.1	4.8
3	Nicotine sulfate+.5 cc. n/1 NaOH	42.7	13.7	trace
4	Nicotine sulfate in tap water	51.5	15.7	trace
5	Nicotine sulfate in tap water plus soap equal to 4lbs per 100 gallons	36.6	8.9	3.0
6	Nicotine sulfate+.75 cc. n/1 NaOH	27.9	trace	trace
7	Nicotine sulfate+1.0 cc. n/1 NaOH	10.4	trace	0
8	Free nicotine+.013 gm. Na_2SO_4	14.1	0	0
B	Cloudy and rainy weather			
1	Descriptive matter as above	82.6	46.1	13.4
2		52.7	18.5	7.0
3		26.9	7.7	6.0
4		35.8	12.5	19.0
5		33.2	7.4	0
6		15.5	trace	trace
7		17.9	0	trace
8		41.9	trace	2.7

exception of number 2, a nicotine sulfate solution made in the laboratory from pure nicotine combined with standard sulfuric acid to neutrality with phenolred. One cc. of this solution equaled .166 gm. nicotine. Number 1 was a neutral solution of nicotine sulfate in distilled water. Numbers 2, 3, 6 and 8 were four graduations of the ncessary amount of alkali necessary to equalize the combining acid. Numbers 4 and 5 are the same as number 1 except in the use of tap water and of soap. One and two-tenths cc. of each solution were made up to 5 cc. and applied with an atomizer to a large leaf, and after definite periods of time the remaining nicotine was washed off and the amount determined. The final test was made in an open laboratory, where the air had free circulation but where precipitation during the experiment could not wash off the nicotine. The leaves while fresh were suspended from a cord and the spray applied to the surface. Field tests on living plants gave similar results to these but attempts to get comparative data with low and high humidity were impractical on account of slight precipitation.

The data[1] on volatilization are given in Table I, in which will be found a comparison of the loss of nicotine in clear weather with a low humidity and rainy weather with high relative humidity. From this data, it will be seen that there is a marked difference between the volatility rate in clear and rainy weather. This is due in part to the slower evaporation rate of water during high atmospheric humidity, thus holding the nicotine longer in solution and hindering its volatilization. It is also possible that nicotine volatilizes more rapidly from the dry film in low atmospheric humidity. The difference in volatility between free (levorotatory) nicotine and the salt form (dextrorotatory) is very marked. The former after 24 hours has volatilized to the extent that only traces are found even by very delicate chemical tests, the range of recovery for the latter being from 29.9 to 46.1 per cent. This proves that the full amount of nicotine from a properly made spray is released in 24 hours and that from 85 to 90 per cent is available in the first three hours during clear weather, while the alkaloid combined with an acid may lack from 13 to 19 per cent of being volatilized after 48 hours of cloudy weather. Such long periods required for activation necessarily reduce the efficiency of a spray in two ways: the concentration of nicotine released may not be high enough at any one time to become

[1]All nicotine determinations were made by the silicotungstic acid method as reported by Chapin, U. S. Department of Agriculture, Bureau of Animal Industry, Bul. 133.

toxic, or rain may wash off an application or dilute it to a point of inefficiency.

It should be noted that a reduction in the amount of nicotine in solutions recovered from sprayed leaves is not necessarily due alone to volatilization but probably includes oxidation into other compounds. Nicotine oxidizes readily, turning brown when exposed to air. Under the action of oxidizing agents it yields a different product. The oxidation of nicotine seems to occur only when exposed to large quantities of air or over a considerable period of time. For example, in aspirating two to four hundred liters of air through a nicotine solution, and where the volatile nicotine passed through two or three feet of rubber tubing, it was only in rare cases that even a trace of nicotine was recovered in the washing liquid, but a close correlation was found between the amount of volatile nicotine recovered with damp silicotungstic paper, at the top of the tube, and that remaining in solution at the bottom of a short, closed, glass tube. This shows that the nicotine from a dust or spray that is in close proximity to the body of an insect would enter the tracheae unchanged but as the nicotine dissipates in the air it is soon oxidized.

Spraying Experiments. Nicotine solutions with varying alkalinity were used as in Table I., but at dilutions of one to one thousand. This concentration was chosen rather than a stronger one as complete mortality was not desired in any of the experiments. Concentration of one to eight hundred gave one hundred per cent efficiency on certain species of aphids with numbers 7 and 8. A neutral solution of nicotine sulfate was used which had been prepared in the laboratory as was also the free nicotine used in number 8. The latter contained an amount of sodium sulfate equivalent to that formed in number 7 by the addition of the neutralizing sodium hydroxide. Distilled water was used in all cases except as noted. The spray was applied by means of an atomizer. Two counts were found necessary as a twenty-four-hour exposure did not give the full effect of the nicotine.

A close correlation is noted in the percentage of mortality between those containing free nicotine (numbers 7 and 8), the latter by reason of the neutralizing alkali added. The lowest efficiency was noted in the nicotine sulfate (dextrorotatory nicotine) solution, thus proving that volatility is a primary factor in the toxicity of nicotine. The results in numbers 4 and 5 show the danger of depending entirely on natural alkalinity or the variable amount found in soap, for releasing all the nicotine.

FUMIGATION EXPERIMENTS. The same solutions were used in this as in the spraying tests, the difference being alone in the method of application. Five cc. of each solution were placed at the bottom of a glass cylinder one and one-half inches in diameter and six inches high. Infested leaves were placed inside the upper end of the cylinder, about four inches from the solution. The upper end of the cylinder was then closed with a cork. Exposure was for the same length of time as in spraying. The data given in Table II show a close correlation between the effect of spraying and fumigating,—further proof of the relation between volatility and toxicity, and also that nicotine is a tracheal rather than a true contact insecticide.

TABLE II. TOXICITY TO APHIDS[2] FROM SPRAYING AND FROM FUMIGATING WITH NICOTINE SULFATE IN SOLUTIONS OF VARYING ALKALINITY

No.	pH value	Nature of Solution	*Percent. of Aphids dead*	
			Spraying	Fumigation
1	6.5	Nicotine as sulfate, 1–1000, distilled water	53.6	48.1
2	6.7	Nicotine as sulfate, 1–1000 plus 2.4 cc. n/1 NaOH, in distilled water	49.7	55.5
3	7.2	Nicotine as sulfate, 1–1000 plus 4.8 cc. n/1 NaOH, in distilled water	60.9	58.9
4	7.4	Nicotine as sulfate, 1–1000 in tap water	51.0	62.9
5	7.6	Nicotine as sulfate, 1–1000 in tap water plus soap at the rate of 4 lbs per 100 gals.	65.3	66.6
6	7.8	Nicotine as sulfate, 1–1000 plus 7.2 cc. n/1 NaOH, in distilled water	65.4	88.4
7	7.9	Nicotine (free) 1–1000, plus an amount of sodium sulfate equivalent to that formed in No. 6, in distilled water	74.6	82.9
8	8.2	Nicotine as sulfate, 1–1000 plus 9.6 cc. n/1 NaOH, in distilled water	76.5	75.7
Check		Untreated aphids	7.7	22.3

[2]Ivy aphid (*Aphis hederae* Kalt.). Green peach aphid (*Rhopalosiphum persicae* Sulzer).

SUMMARY. The graph shows the similarity between the loss of nicotine as determined chemically in the volatilization tests and the bio-assays in fumigating and spraying experiments. These curves are averages of from two to four series, where the same type of solutions have been tested in slightly different ways or on different species of aphids. Larger series would show more regularity in the curves but sufficient work has been done to prove the correlation between volatility and toxicity. This also shows the value of a slight addition of alkali to solutions of nicotine salts to supplement the alkalinity of the tap water, which in most instances is insuffiicent for freeing the nicotine from combining acids. The use of free nicotine, of course, obviates the

need of such addition but this form of nicotine in the concentrate is much more dangerous to handle and is subject to greater losses in evaporation.

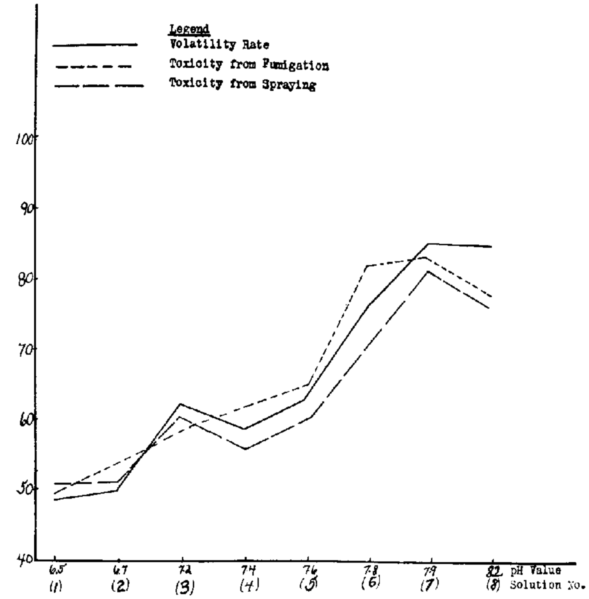

Fig. 5—Graph showing volatility rate and comparative toxicity from fumigation and spraying.

Practical Applications. To obtain the maximum efficiency of nicotine sulfate solutions, a slight excess of alkali should be added over the amount needed to combine with the sulfuric acid present. To one pound of nicotine sulfate add three ounces of hydrated lime or freshly slaked burned lime. Then for a two-hundred gallon tank of 1-800 solution of nicotine sulfate, 6¾ ounces of lime would be required, supposing the nicotine solution had a specific gravity of 1.2. If soap is used as the spreader, then add three ounces of sodium hydroxide (commercial lye may be substituted) or four ounces of sodium carbonate. One of the most convenient forms for the latter is commercial soda ash.

Waters that are very alkaline might, with the addition of soap or calcium caseinate, neutralize the combining acid present. However, such waters are not common and, in most instances, the total alkali

present is insufficient to free the alkaloid. Since we have no method of determining easily when the alkaloid is completely freed, the safest plan is to add a slight excess of alkali. If calcium caseinate is used as a spreader, it might be possible to reduce the amount of alkali added, but since many waters contain considerable quantities of carbonates or other lime-precipitating chemicals too much dependence should not be placed on the excess alkali in casein spreaders.

Nicotine Dusts

The use of dust carriers for nicotine instead of water, as developed by Professor R. E. Smith, has been a great advantage in certain types of work but with it have come some complicated problems. This is due to three reasons: first, the dilutant is at present sold with the nicotine

Table III. Volatility of Nicotine in Various Dust Carriers.[3]

No.	Form of Nicotine	Carrier		Time of Exposure	Pct. of Nicotine Recovered
		Substance	Proportion		
			per cent	Hours	
1	Free nicotine	Hydrated lime Sulfur	74.7 24.2	18	22.3
2	Free nicotine	Hydrated lime Sulfur	49.5 49.5	18	25.3
3	Free nicotine	Hydrated lime Sulfur	87.8 11.2	18	32.1
4	Free nicotine	Hydrated lime Sulfur	11.2 87.8	18	trace
5	Free nicotine	Sulfur	99.0	18	none
6	Free nicotine	Hydrated lime	99.0	18	45.7
7	Free nicotine	Sodium carbonate	99.0	18	none
8	Free nicotine	Kaolin	99.0	18	96.3
9	Free nicotine	Hydrated lime Water	94.95 4.05	18	54.6
10	Nicotine sulfate	Kaolin	97.5	18	100.0
11	Nicotine sulfate	Hydrated lime	97.5	18	25.1
12	Nicotine sulfate	Sodium carbonate	97.5	18	none
13	Nicotine sulfate	Ammonium carbonate	97.5	18	none
14	Nicotine sulfate	Hydrated lime Sodium carbonate	48.7 48.7	18	trace

[3]Temperature range 58° to 70° F.

and at a high price; second, the release of nicotine from dusts varies with the type used and to a certain extent with the amount of moisture present; third, the stability of the nicotine as found in nicotine sulfate solutions is lost when alkali is added to "activate" it. Free nicotine is so volatile and subject to chemical changes that it has thus far been impossible to store it for any length of time without loss. This emphasizes the value of the "self-mixing" duster which gives immediate use of the nicotine when first freed. Since volatility and toxicity are so closely related, it is apparent that a dust which releases nicotine very quickly is desired for high concentrations of volatile nicotine over short periods of time rather than a slow release over an extended period. To quote Professor Smith, "The greatest possibility of reducing the amount of nicotine used lies along the line of making it as quickly volatile as possible."

The data given in Table III show that the hydroxide compound releases the nicotine more slowly than the carbonates. Hydrated lime ($Ca(OH)_2$) gave a slower release of nicotine both in free and sulfate forms than did calcium or sodium carbonate (Na_2Co_3). This agrees with the analyses given by Thatcher and Streeter (N. Y. Exp. Sta. Bul. 501). Professor Smith states in California Experiment Station Bulletin 336, that "Lime carbonate makes a very satisfactory filler but has no effect upon nicotine sulfate . . . . . Hydrated lime reacts with nicotine sulfate, forming free nicotine." The carbonate of lime which Smith was using was principally waste forms of lime which may account for the difference in results. Limited spraying tests with these two bases confirm the chemical analysis, i. e., the carbonate carrier is superior to the hydrate.

A comparison of free nicotine and nicotine sulfate is also given and so far as the tests are completed, do not indicate a material difference between these two forms of nicotine. It will be noted that free nicotine is less volatile with hydrated lime as a carrier than is nicotine sulfate from carbonate carriers. It is doubtful whether the added danger to the operator and the possibility of loss by volatilization would warrant the substitution of free nicotine for the acid compounds in the making of dusts, at least in the present stage of experimentation.

Chairman R. E. CAMPBELL: The next paper on spraying equipment for citrus trees will be presented by Mr. Herbert.

SPRAYING EQUIPMENT FOR CITRUS TREES IN CALIFORNIA

By Frank B. Herbert, *Assistant Entomologist, Balfour Guthrie & Co.*

Abstract

There are two citrus districts in California,—Tulare County with medium sized open trees, where good results can be obtained with usual four horsepower spray machine,—and Southern California, with larger, denser trees, where the largest orchard sprayers (10 horsepower), are required. These machines have a capacity of 15 to 20 gallons per minute and carry 350 and more pounds pressure. Spray guns are used almost exclusively, with disc apertures ranging from $\frac{7}{64}$ to $\frac{9}{64}$ inches.

In Tulare County the average tree requires 8 to 10 gallons of solution, making a cost of 4 to 15 cents per tree for the application, and in Southern California, requiring 12 to 15 gallons, making the cost of applying run from 6 to 19 cents per tree.

From time to time growers and county officers have requested data on spraying equipment for citrus trees, with special reference to the pressure desirable, size of gun discs, number of gallons required per tree, cost of application, etc. Therefore the writer has endeavored to record some of the requirements in this paper, the data being taken from the records of sprayers and from general experience, and not from any special experiments performed.

Citrus Districts

There are two distinct citrus districts in California. Southern California, where spraying on a large scale for any pests except red spiders, is quite new, and Tulare County, where spraying has been the principal means of pest control for a number of years. Full grown citrus trees in the former district become very large and require special equipment in order to properly cover them, while those in Tulare County average much smaller and can be more easily covered with the ordinary sized spray machine.

Type of Machine

A great deal of the spraying in Tulare County is done by the individual grower who owns his own spray rig and does his work when he pleases. Most of these machines are of the larger sizes having single cylinder engines throwing from 8 to 12 gallons per minute. The "Bean" has been the favorite in this territory until now the "Friend" is coming to the front. As most of the trees are not over 15 feet high and are fairly open, the grower has been able to get by very well with this sized outfit. In quite a few cases the grower uses only one gun with this machine.

South of the Tehachapi, the commercial sprayer has been doing the bulk of the spraying, partly because it is a new business and partly because the trees have been so large that they required a large machine which the ordinary grower has not felt he could afford. Some of the smaller machines, which were used for spider spraying, are still in use,

but all the larger growers and commercial sprayers are demanding the largest orchard sprayers on the market, such as the Friend AXA, the Bean Super-Giant, and the Hardie Mogul. The Friend is the favorite here, having the largest capacity, besides being able to carry a pressure of 350 pounds or more with a minimum amount of upkeep. Each of these machines has a capacity of 15 to 20 gallons per minute and throws ample material to take care of two or more guns.

The sprayer when purchasing a new spraying outfit should not consider the initial cost alone, for with the cost of upkeep, the cheapest outfit is liable to more than balance the cost of the highest priced rig, without considering the aggravation and time lost from a poor machine. This applies particularly to the commercial sprayer, who must make every hour and dollar count for his season is short enough at best. The writer knows personally of a number of outfits requiring over $300.00 for upkeep per year, while more durable machines required only $10.00 to $35.00 for the same period.

Pressure

No one should attempt to operate a machine which will not carry at least 300 pounds pressure. This amount will suffice on small to medium sized open trees, but the best results on large trees have been obtained from machines carrying 350 to 400 pounds. A 130 acre grove of large trees in the Redlands section was classed as a 99.6 percent kill on Citricola scale last season. This had been sprayed with two medium sized rigs, but these results were obtained only by the most diligent work under and outside the tree, the sprayers even using ladders to reach the tops. The same results could have been obtained much more easily by using a rig with high capacity and pressure. Moreover this is the only grove of large trees where the writer knows of any such kill with a small rig. There have been a great many kills of better than 99 percent obtained much more easily where large outfits were used.

Spray Guns

The old time rod and nozzles have been replaced practically entirely by spray guns. If there is any occasion where the gun is more efficient than the rod, it is in spraying citrus trees. With the proper amount of pressure, the gun will break the material up and carry it to the tops of the tallest treess, and still do it more economically than any rod and nozzle. One hears occasionally from an "old timer" that he could do the same work and use less material with a rod. True, it could be done well with a rod, but only with the expenditure of a greater amount of energy and fully as much material. The only reason the rod might use

less material would be because the ordinary man hasn't the patience to stay at a large tree long enough with it to properly wet all the foliage. The gun will give a better washing and drenching effect on the tree than the rod.

The Friend and Hardie guns have proved to be the most popular makes. The Boyce double gun has been tried out to some extent, but has not proven to be any great success, except for medium sized open trees or for outside work, such as spraying for thrips. In inside work, which is essential in spraying for scale on citrus trees, the double gun gets caught to some extent on the foliage, and is tiresome to hold due to its heavy head. This same fault is found with the rod.

On the large machines the size of the aperature in the gun discs should be from $\frac{7}{64}$ to $\frac{9}{64}$ inches. If the machine is able to hold up its pressure with the larger discs, the more satisfactory will be the application for the greater the volume being forced through the gun, the farther the material can be thrown and this is essential on large trees. If at any time the material is being thrown too far, a simple turn of the handle widens the spray and shortens the distance it is thrown. With the smaller machines one should use one gun with a large disc or two with smaller discs, ranging from $\frac{4}{64}$ to $\frac{7}{64}$ inches. No gun should be used at less than 300 pounds pressure.

Hose

Some trouble has been experienced in getting hose to stand up under the high pressure used in Southern California. We find it must be at least seven ply and sometimes even this will give trouble in some brands. Half inch hose is used mostly, although a few of the large machines are equipped with $\frac{5}{8}$ inch material. The latter throws a nicer stream due to less friction, although it is considerably heavier to drag around. Two fifty-foot lengths are the usual equipment on each outfit.

Gallonage per Tree

In Tulare County the average amount of material required per tree is from 8 to 10 gallons. In some groves, 16 or 18 gallons are required to thoroughly drench the trees. In Southern California the trees average much larger, requiring 12 to 15 gallons, while some groves require as high as 25 gallons per tree. Individual trees have been seen that have had as high as 42 gallons applied before they were properly covered.

With small trees, two year olds require about one gallon each, 4 year olds, 2 gallons, 6 year olds, 4 to 5 gallons, with some of the thriftier taking as high as 10 gallons.

Cost of Application

Figuring in everything, it costs the grower who runs his own machine from ½ to $\frac{7}{10}$ cents per gallon to apply the spray, while the commercial sprayer charges from 1 to 1¼ cents per gallon, most of them charging the latter.

Thus the cost of application on the average tree in Tulare county is 4 to 7 cents where the grower owns his own rig, or 8 to 15 cents when hired done by a commercial sprayer. In Southern California the average cost runs from 6 to 10 cents for the grower, and from 12 to 19 cents for the sprayer.

This was followed by a paper by Mr. R. E. Campbell.

NOTES ON NICOTINE DUST PROGRESS

By Roy E. Campbell, *U. S. Bureau of Entomology*

Abstract

This general historical account of the use of nicotine in dusts, is given with special reference to recent developments, the properties of carriers, the utilization of finely ground tobacco dust, the comparative merits of free nicotine and nicotine sulphate, the advisability of a certain amount of moisture, the mechanical devices for the application of dusts, data on self-mixing dusters and the possibilities of local mixing. An extended bibliography is given.

When ground tobacco dust, because of variation and slow release of its nicotine content, failed to satisfactorily control the walnut aphis, Professor Ralph E. Smith began the use of a dust containing a definite amount of standardized nicotine sulphate solution added to a dry carrier. Following that work, the use of nicotine dust was taken up by the Federal Bureau of Entomology, and soon afterward investigations were also started in California, New York, New Jersey, Virginia, Connecticut, Ohio, Missouri, Maryland, Wisconsin, and other States. It is doubtful if in recent years any insecticide has aroused so much interest on the part of the economic workers as nicotine dust.

Kaolin was first used as a carrier because of its availability, ease of grinding, and inertness. It was found, however, because of its compound nature, to adsorb and "tie up" too much of the nicotine, and lime, being less subject to this objection, was substituted. Refuse sugar-beet lime and hydrated lime, together with finely-ground sulphur, also have been used most extensively. More recently the carbonates of lime and magnesia have proved to have certain advantages, particularly in giving off the nicotine very readily. A combination of these occurs naturally in dolomite, which is coming into favor as a carrier.

It soon became evident, after conducting many experiments and ob-

serving the results of others, that the entomologist had gone about as far as possible with the problem of carriers for nicotine dust. It was necessary for the chemist to investigate the nature of the reactions between the nicotine solutions and the different carriers. Experimental evidence indicated that nicotine dust was more effective when made up with certain carriers than with others, but the exact reasons were not well understood. As a result of the excellent work recently done by the economic workers of New York and New Jersey, we now know which carriers are active; i. e. (1) those which actually cause the nicotine to be released quickly; (2) those which are inactive and have no effect on the nicotine, except to expose it for evaporation, and (3) those which adsorb the nicotine and retard its release. It was also demonstrated that there is a difference in the reaction of nicotine sulphate and free nicotine to some of the carriers, and that the moisture content of the carriers affects dust made from the two types of nicotine differently. The entomologist can now proceed to find out whether a very quick release of the nicotine or a more gradual release gives the best killing, and whether free nicotine or nicotine sulphate makes the most effective dust. Probably these will differ in killing power when applied to different forms of insects under varying conditions.

The problem is further complicated from the manufacturer's viewpoint, who does not wish to make a dust which may lose its nicotine if held in storage for several months, nor a dust which retains the nicotine after the material has been applied. The ideal carrier would be one which retains the nicotine indefinitely in storage, but releases it readily when the dust is applied to plants. Perhaps the chemist may find some material, or combinations of material, suitable for such a carrier.

Nicotine dust was first manufactured by a cooperative walnut growers' association in 1918 at Santa Barbara, Cal. It proves so successful that a subsidiary company of the California Walnut Growers' Association was formed to make dust not only for its own growers, but for growers of fruit and vegetables as well. Since then the production has increased until there are at least five manufacturers of nicotine dust in the western, and six in the eastern United States. The total production of nicotine dust is shown as follows:

TABLE I. TOTAL PRODUCTION OF NICOTINE DUST IN THE UNITED STATES

Year	1919	1920	1921	1922	1923
Number of factories	1	2	3	8	11
Tons produced	400	225	425	970	1925*

*Production from one factory estimated for 1921, 1922 and 1923.

An interesting fact has occurred as a result of the rapid increase of nicotine dusting. It might be supposed, because of the large amount of nicotine used in the dust form, that liquid spraying with this material had decreased. On the contrary, the use of nicotine in dust form seems actually to have stimulated its use as a liquid spray, for more is being sold for this purpose than ever before.

Another development is a stimulation of the use of ground tobacco dust. Some manufacturers have advertised this material, but because of the variable amount of nicotine in ground tobacco and also because it does not volatilize so readily, its use has not been entirely successful. Recent experiments performed in New York with a finely-ground tobacco indicate that while on the basis of its nicotine content, ground tobacco is more expensive and slightly less active than nicotine dust, yet it gives sufficiently satisfactory results to be worthy of further investigation.

For several years the source of nicotine for all dusts was a solution of nicotine sulphate containing 40 per cent of nicotine. With this it was customary to use some hydrated lime, or other "active" material, which caused a reaction and liberated the nicotine. Recently some manufacturers are utilizing a solution of free nicotine which eliminates the need of using an "activator." There is a tendency also toward the use of a solution containing a higher percentage of nicotine. Some manufacturers claim better results with the free nicotine than with the sulphate, while others who continue the use of the sulphate, maintain that it is the most satisfactory. The free nicotine solution is a little more expensive, and the increase in the concentration of nicotine also increases its cost per unit. Recent experiments in New Jersey have demonstrated that a dust made of dolomite and free nicotine gave a better killing than one composed of hydrated lime and nicotine sulphate. The superiority of the free nicotine dust was due to a greater evolution of gas in a given period of time. It has also been demonstrated that nicotine sulphate in a dolomite carrier releases its nicotine more rapidly than in hydrated lime, so that the comparison of the two types of nicotine in two different carriers is not conclusive.

A certain amount of moisture is desirable in nicotine dust when compounded with nicotine sulphate, as the reaction is thereby hastened, but too much moisture is disadvantageous, because some of the nicotine may be dissolved. It is difficult also to thoroughly incorporate such a quantity of liquid into the carrier, without resulting in a dust which is too moist for satisfactory application. The presence of moisture is

especially undesirable in dust made with free nicotine, as the moisture has a tendency to absorb the nicotine. An excess of moisture may be partially overcome, in some cases, by the use of a drier, such as quick-lime or plaster of Paris, but here complications may arise because of the action of these driers on the nicotine. The use of a solution containing a higher concentration of nicotine would, of course, remove both of the above objections in making high-strength dusts, but it in turn is objectionable because of the higher cost of the nicotine.

When the practice of applying nicotine dust as an insecticide was first begun, the only machines available were those which had been developed for dusting with arsenate of lead and sulphur. These machines were utilized for nicotine dusting, and were gradually improved to give a better feed of dust and a larger volume of air, since usually it was desirable to apply a greater amount of nicotine dust than of materials previously used, and in most cases to run the dust through the fan itself, thus breaking up any lumps which might have remained in the mixture. In addition, booms were perfected to apply the dust to rows or field crops as the machine was driven over them.

In order to hold the dust as long as possible around low-growing plants and at the same time to overcome the effects of wind blowing away the dust or fumes, several devices were made. One was a box-like enclosure, entirely surrounding the machine, into which the dust was discharged through individual pipes leading to the rows. Another device consisted in merely attaching a piece of canvas, a little wider than the strip of rows to be covered, to the back of the duster, and allow the canvas to trail behind. The canvas not only holds down the dust about the plants, but in dragging it over them, it knocks off many insects such as aphids. The increased activity of the aphids, in crawling about on the ground or the plants, renders them more susceptible to the action of nicotine. Some have used trailers 15 to 20 feet long, but the writer has obtained best results on peas infested by the pea aphis with one 40 feet long. The only limit to the length of the canvas trailer is the ease of handling it in turning at the ends of the rows. The canvas must not be long enough or heavy enough to injure the plants. It has been found advisable also to hang a weighted piece of canvas just ahead of the nozzles. This reaches below the tops of the plants and prevents the dust from escaping in front.

Other devices have been used, such as U-shaped inverted troughs, 4 feet long, attached to the rear of the dusting machine. A trough covers each row to be treated, and the dust is discharged into it. As

the machine proceeds down the rows, the troughs prevent the escape of most of the dust. These troughs are especially useful in windy weather.

Early in his work with nicotine dust, Professor Smith conceived the idea of a self-mixing duster, in which the nicotine solution and carrier could be mixed at the time of application. During the 1922 season such a machine was developed, being an adaptation of one of the regular dusters on the market. Early in 1923 two different firms began the manufacture of self-mixing dusters. Both of these have been tested, and while subject to some mechanical imperfections, as might be expected in new machines, the success of self-mixing dusters was demonstrated. The advantages of self-mixed dust are as follows: (1) The dust is much cheaper, being limited to the cost of raw products only; (2) it is perfectly fresh; (3) it is hot from the mixing and chemical reactions, and therefore more active; (4) there is no loss of nicotine from storage, and (5) it is possible to make quickly any strength desired. Of course, there still will be a large demand for the ready-made dusts, for use in the machines not suited for self-mixing, and in hand dusters. Many growers do not care to take the time and trouble of mixing their own materials, while others feel that with the type of labor available in some localities, the possibility of using the wrong dosage and improper mixing will be too great. The self-mixing dusters can be used for applying ready-made dusts, arsenate of lead, sulphur, or other necessary material.

Considerable emphasis has been placed on the thoroughness of mixing nicotine dust, and many have doubted if the self-mixing machines would do this satisfactorily. Professor Smith recently tested this by placing 40 pounds of hydrated lime and 2 pounds of 40 per cent nicotine sulphate solution in the hopper and running the machine for two minutes. A sample was then taken from near the top and one from near the bottom of the hopper. The machine was then run 8 minutes and two more samples taken. These were analyzed by the California State Department of Agriculture and showed the following percentages of nicotine: 1.88, 1.89, 1.88 and 1.87, thus definitely proving the evenness and thoroughness of the self-mixing operation.[1]

A later analysis gave the following results:

[1]Data from personal correspondence.

TABLE II. ANALYSES OF NICOTINE DUST FROM SELF-MIXING DUSTER. DUST MADE WITH 2 POUNDS OF 40 PER CENT NICOTINE SULPHATE AND 50 POUNDS LIME

Sample	Time of mixing	Remarks	Sample taken from	Nicotine content
1	1 minute	Lumps discarded		1.41 per ct.
A	2 minutes		Side	1.23 "
B	2 "		Center	1.49 "
C	2 "		Deep center.	1.44 "
D	2 "		Side	1.38 "
E	2 "		Center	1.59 "
X	2 "	Ran 1 min. lumpy Then ran 2 mins.		1.59 "
B3	3 "			1.56 "
B31	3 "			1.56 "
B3c	3 "		Deep center	1.43 "
B3s	3 "		Side	1.41 "
B3T	3 "		Top	1.54 "

A recent development in the distribution of this compound has been local manufacture of nicotine dust. This involves both mixing and distribution by local dealers or growers and makes available high grade dust in small quantities.

Nicotine dust prepared by a large manufacturer and shipped long distances is necessarily somewhat high-priced. To the cost of making and the manufacturer's profit, must be added necessary profits for the distributor and retailer, which, with rather high freight rates, may make the price per pound almost double the actual cost of the raw materials.

Mixing machinery is neither very expensive nor complicated. As a consequence, local dealers in communities where there is considerable demand for nicotine dust, especially where they are located at some distance from a manufacturer, are installing their own machinery, and buying the raw products, mixing and selling the dust directly to the growers. When this is done the distributor's profit, and often the retailer's profit can be deducted, as well as the freight charges, which permits the sale of the dust at a very low rate.

The large manufacturer can, of course, compete with such local manufacturers by installing mixing machinery at his branch houses, and by dealing directly with retailers or growers, thus eliminating freight rates for long hauls on the manufactured dust, and also the distributor's or jobber's profit. It is probable that ultimately most of the nicotine dust will be made either in the self-mixing machines, or by a number of comparatively small local manufacturers, distributed over

the country, and that such manufactured dust will be used within a territory a few hundred miles from the factory.

Such manufacturers will have the advantage of being able to sell cheaply to local trade and to make up an order and quickly send out freshly-made dust, thus largely eliminating the possible deterioration while in storage, and furthermore will be able to specialize on the type of dust best suited to their particular localities.

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A discussion on dusts was led by Mr. Campbell. Among other things there arose the question as to when an entomologist should recommend control measures. Some differences of opinion developed, but it was generally felt that insects with only one or possibly two generations a year must be considered differently than those with many generations and which develop serious infestations in a few weeks. It was finally agreed that the best rule to follow was to consider the infested crop or orchard as if owned by the entomologist and make control recommendations accordingly.

Meeting adjourned.

Afternoon Session, September 18, 1923

The excursion, previously announced, was attended by 30 members and visitors, who were shown the process of manufacturing nicodust and dusting machines, liquid hydrocyanic acid gas and calcium cyanide, and the methods of propagating and rearing parasites and predaceous insects for biological control.

Morning Session, September 19, 1923

The meeting was called to order by chairman R. E. Campbell who announced the order of business as a symposium on biological control under the leadership of H. S. Smith, in charge of Beneficial Insect Investigations, Univ. of Calif.

The following papers were presented:

WHAT MAY WE EXPECT FROM BIOLOGICAL CONTROL?

By Harry S. Smith, *University of California, Citrus Experiment Station*

Abstract

Biological control work has been subject to extremes of popular approval and disapproval. This is due to a lack of understanding, on the part of the general public, of just what results may reasonably be expected from this method. Success is dependent upon biological principles with which the grower is not always familiar. Some insect pests are favorable subjects for attack by this method and others are not. It is pointed out that the proper co-relation between host and parasite and freedom from secondary parasites, are important factors in this type of control. The future is bright for this branch of economic entomology.

The control of citrus pests by the use of their natural enemies is a phase of scientific agriculture which has appealed to California growers for many years. At no time since the introduction of the Australian ladybird, Vedalia, in the early 80's, which resulted in the saving of the citrus industry from the ravages of the cottony cushion scale, has the California fruit grower lost interest in this method of pest control. His interest in the subject has not, however, been at a uniformly high pitch during this entire period. The introduction of Vedalia was naturally followed by a wave of enthusiasm for the introduction of parasites, not alone among growers but among some entomologists as well, which, as we have since learned, was hardly justified but which is easily understood in view of the striking results of this introduction. During this period the feeling was quite general in California that any pest could be controlled simply by the introduction of *its parasite*.

For several years after the introduction of Vedalia enthusiasm was high; but failure to secure similar results with other insect pests had its effect and interest began to slacken somewhat. Then Scutellista, a parasite of the black scale, was introduced from South Africa in 1902.

This parasite thrived wonderfully under California conditions and gave promise for a time of doing to the black scale what the Vedalia did to the cottony cushion scale. As time passed, however, and the black scale failed to disappear from the orchards in spite of comparatively heavy parasitism, this second wave of enthusiasm for the biological method of pest control began to lose its force. From then until 1918 was a period during which there was no more than a very general interest in this method. In 1918 the work of the California State Department of Agriculture on the biological control of the citrus mealybug began to make itself felt and interest in this subject began to reawaken. It was not, however, until the successful introduction and establishment by the Department of *Aphycus lounsburyi* Howard as an aid in the control of black scale, that interest in biological control again reached its height. History repeated itself, and there was a tendency again to expect greater results than the facts in the case warranted. However, this wave of what might be termed "over-enthusiasm" has receded, and there is now, I believe, a pretty general understanding on the part of the growers of just what may reasonably be expected in the way of control of the black scale by Aphycus.

My purpose in calling attention to the effect on the interest of the fruit grower of these various efforts to control pests by the biological method is to bring about a better understanding as to just what part natural enemies should play in our general scheme of pest control. Over-enthusiasm generally has a reaction which is not beneficial. The greatest good will come from biological control only when the majority of our agriculturists have a better understanding of the principles involved and the limitations to which the work is subject.

In appraising the possible value of the biological method as a pest control measure, there are certain more or less fundamental biological principles which must be taken into consideration.

In the first place, just what is meant by "biological control?" It means the suppression of insect pests by the use or encouragement of those organisms which in nature tend to reduce their numbers. All forms of life are subject to the action of factors which limit their increase. The most important of these are meteorological conditions, which include heat, rain, cold and drought; limited food supply; fungous and bacterial diseases, which destroy numbers of insects, especially in the more humid climates; and predatory and parasitic enemies. These various limiting factors taken together form what is known as "natural control."

On account of the fact that in California fungous and bacterial diseases of insects do not generally thrive, biological control in this state resolves itself into a matter of making use of beneficial insects alone.

While all insects have natural control factors working against them, they do not all have natural enemies among the parasitic and predatory insects, at least not effective ones.

Some insects are serious pests not because they have been introduced from a foreign country without their natural enemies, but because man has altered their environment in such a way as to provide a more satisfactory habitat and food. The Colorado potato beetle is a good example of this type. It is a native of the plains region at the base of the Rocky Mountains and its native food plant is the sand-bur, *Solanum rostratum*, a plant related to the potato. Upon the introduction of the potato, this beetle transferred its attention to that plant, and finding it much more to its liking, was able to multiply more rapidly and thus developed into a serious pest. A somewhat similar case is that of the grape Phylloxera, which is also a native insect and which became an important pest because of the introduction into the United States of the *vinifera* varieties of grapes from Europe, a type of grape which was a more favorable food plant than the native American grapes and which had developed no immunity to the pest.

Neither of these insects has natural enemies of importance and therefore the biological method is not applicable so far as at present understood. I cite these two cases merely to emphasize the fact that there are certain pests against which there is apparently no possibility of using this method in a practical way.

A general study of the problem indicates that the relative importance of insect enemies in the natural control of pests varies all the way from practically nothing, as in the cases above cited, to the most important of all factors making up natural control, as exemplified in the case of the Vedalia and the cottony cushion or fluted scale. Since, in California at least, the application of the biological method is practically confined to the use of insect enemies, the applicability of this method to the control of pests is dependent upon the availability of effective parasitic and predacious insects. It should be plain therefore that the degree of control which may be effected, may vary all the way from nothing to practically complete control, depending upon (1) whether or not effective natural enemies exist, and (2) whether introduced natural enemies find climatic and other environmental conditions satisfactory for their multiplication in their new habitat. This is, of course, a

statement of perfectly obvious facts, but there are many complications which enter into the situation and determine the *degree* of control which may be brought about.

Assuming that natural enemies of apparent value are located and successfully shipped to destination, that their life-history and habits are definitely determined and that a sufficient breeding stock is on hand, upon what conditions does practical success depend? Among known factors which bear on this question the following are important:

There must be the proper co-relation between the life-history of the parasite and that of the pest. No better demonstration of this principle could be asked than that exhibited by the black scale and the Aphycus. Aphycus thrives in the coastal areas of the state, where the life-history of the black scale is such that the stages of development upon which Aphycus is able to breed exist at all times of the year. On the other hand, it does not thrive in the interior, where for several months at a time these stages are not present and the parasite is therefore unable to maintain itself in abundance for lack of the proper hosts. This principle is fundamental. It is conceivable however that we may find parasites whose life-histories more nearly correspond to that of the black scale under interior conditions. The same is probably true of the citricola scale, which has only one generation a year. On the other hand the red and purple scales have several generations per year and from this standpoint are more favorable subjects for biological control. Because most scale parasites are short-lived and must pass through several generations a year to maintain themselves in abundance, it follows that scale insects such as the red and purple scales, the black scale under coastal conditions and the mealybugs are more favorable subjects for biological control than are such pests as the citricola scale or the black scale under interior conditions. There are however two possibilities by which these latter pests might be brought under control by the biological method. We may succeed in finding parasites which have life-histories corresponding to that of these scales or predators which feed on all stages, or we may develop methods of propagation of the natural enemies in such a way that we can afford to stock the orchards artificially every year with the parasites. The latter procedure may seem far-fetched, but the possibilities of this kind have not been exhausted. The control of these pests costs the citrus growers as much as $50 per acre per year. A very considerable sum could be expended in the production of natural enemies for orchard use, and still leave a margin of profit over fumigation costs, provided, of course, it could be done with equal effectiveness.

The writer is quite free to admit this has not yet been demonstrated except in the case of the mealybug.

The beneficial species which are to be employed must be comparatively free from the retarding effects of secondary parasites existing in the local fauna, which sometimes strongly attack the primary parasites used. Undoubtedly in some cases this factor will be sufficient to render the work unsuccessful, because when by artificial manipulation a superabundance of natural enemies of the pest is created, we thereby form an environment which is favorable for the secondary parasites. In other cases this will merely serve to reduce the degree of control. In most instances it will be practically impossible to foretell just what would happen in this direction and a practical attempt must be made in order to ascertain just what part the secondary parasites would play, and also the primary parasites of predacious insects. Undoubtedly this factor will limit or entirely prevent the control of some of our insect pests by this method. The attack of secondaries which occurred in the local fauna before the introduction of *Aphycus lounsburyi* has already greatly reduced the effectiveness of that valuable parasite, and this was also true in the case of certain parasites introduced into New England by the United States Department of Agriculture for control of the Gipsy moth. We can and do by careful work exclude new secondaries, but there are native secondaries which frequently attack the newly introduced beneficial insects. This of course cannot be prevented.

It seems hardly necessary to state that these two principles, i. e., the adaptability of the beneficial insects to their hosts and their relation to secondary parasites, are the ones on which in a large measure success will depend, and the degree of success attained will vary in accordance with the fulfillment of these requirements. The important thing to be impressed upon the general public, and the thing which has not been generally understood in the past, is that so far as our present knowledge goes not all pests are susceptible to control by the biological method, but that *most of them can be influenced to some extent* by the use of natural enemies, the degree of control being dependent largely upon ecological factors. When this is thoroughly understood there will be less false hope aroused and fewer disappointments and, in the opinion of the writer, the work will be strengthened thereby.

In the actual work of locating new parasites in foreign countries and in collecting, shipping and rearing this foreign parasitic material, many very difficult problems are met. Transportation of material, especially when collected in such far-away places as India, China or South Africa,

is very troublesome even when cold storage is used, and in many instances it has been necessary to persist for several years before a successful shipment is made. The successful shipment of material to this country is only part of the battle. Careful life-history studies of the parasite must be made to determine beyond any doubt that it is a primary in its habits, that is, that it will not attack any of our beneficial species, as the Quaylea does the Aphycus at the present time. With only a very limited supply of breeding stock available and with a parasite of more or less unknown habits, this is difficult and frequently results in the loss of the colony. Often the two sexes do not appear at the same time, with the result that the shipment is finally lost through lack of fertilization of the eggs. Most of these difficulties can however be overcome by sustained effort and are not a permanent barrier to success.

The writer confessses to a feeling of optimism for the future of biological control work. The field has scarcely been scratched. There are thousands of species of beneficial insects throughout the world. There are great improvements to be made in the propagation and manipulation of species already available. The work has its limitations just as does the control of human disease by the use of serums, vaccines and antitoxins, but even partial success will return a large profit on the sum invested in such projects.

THE PRESENT STATUS OF *APHYCUS LOUNSBURYI* HOW. IN SOUTHERN CALIFORNIA

By H. M. Armitage, *University of California, Citrus Experiment Station*

Abstract

In the "uneven hatch" areas secondary parasitism has precluded *Aphycus lounsburyi* How. becoming, by itself, an adequate means of control of black scale, except, possibly, at irregular intervals. Eight hyperparasites are known to attack Aphycus and three others are under suspicion. It is, however, of much value in the uneven-hatch areas as an aid to fumigation by evening up the hatch.

In the interior or "even-hatch" areas, low temperatures which cause retarded development of Aphycus, particularly in the pupal stage, during the one short period when it might alone control the scale, prevents its doing so. Aphycus, with *Scutellista cyanea* and *Rhizobius ventralis*, completes a sequence of enemies attacking the black scale and this fact offers a possiblility of control.

The distribution of *Aphycus lounsburyi* has been so complete, both with and without human agency that it is safe to say there is hardly a citrus orchard, or for that matter a planting of ornamentals or growth of native shrubbery in Southern California, infested with black scale, in which it is not possible to find Aphycus or evidence of its work. In spite of the many factors operating to its disadvantage it is without question a most valuable addition to the parasite fauna of California.

Four years observation on the work of *Aphycus lounsburyi* How. as a parasite of the black scale, following its introduction and successful establishment in the citrus orchards of Southern California by the

State Department of Agriculture in the fall of 1919, have definitely established its limitations as a factor in the control of that pest. They have also corroborated, to a large extent, the results of the work carried on in the early experimental plots and have brought to light a factor, secondary parasitism, which it was hoped might be avoided.

As has been fully explained in the earlier reports of the introduction and establishment of this parasite, two distinct field conditions termed "uneven hatch" and "even hatch," required consideration in determining to just what extent it might become a factor of control. These two field conditions, the first of which embraces the coastal areas in which the scale has one or more overlapping generations, and the second, the interior areas with a single uniform generation must still be considered separately in recording the present status of this parasite.

Coastal or "Uneven-hatch" Conditions

At the time of its introduction it was obvious that the mild climate of the coastal areas together with the overlapping generations of the black scale, offered an ideal condition for the Aphycus to gain the ascendency through rapidly succeeding generations, if it was at all adapted to California's climatic conditions. Little surprise was occasioned, therefore, among those carrying on the work at the rapidity of its spread and the apparent thoroughness of its work in these areas when once established. Appreciating, however, from previous experience with such problems, that newly introduced insects often have an immediate "flare-up" which they are unable to maintain through succeeding seasons, every effort was made not to create any undue enthusiasm among the growers, and in fact this policy was so closely adhered to that it reacted to the extent of the growers taking matters into their own hands. The efficiency of the Aphycus was so obvious to them that they hailed it as a second Vedalia. Wide-spread distribution of field-collected parasites was made through their own organizations. Large tracts of orchard were allowed to go untreated otherwise, in many cases successfully the first two seasons; later, however, there was a heavy loss from the smutting of the fruit and foliage from a heavy infestation of scale; sale of fumigation tents was even considered but fortunately never carried out.

Burdened with an annual fumigation bill running well into seven figures, the growers are perhaps not to be blamed for grasping at such a promising "straw" in their efforts to reduce costs. It is with regret that I find it necessary to record that a factor, secondary parasitism, not entirely unexpected but one which it was hoped might be avoided, has entered into the question and has reduced the efficiency of the Aphycus

in the "uneven-hatch" areas to a point where it cannot alone control the black scale. It is, however, logical to assume that this secondary parasitism will result in the usual cycle, with recurring periods of efficiency on the part of the Aphycus followed by periods of ascendency on the part of the secondaries.

Up to the present time eleven hyperparasites have been taken associated with Aphycus. Eight of these have been demonstrated experimentally in the laboratory to attack the Aphycus, the other three being under suspicion. Those already demonstrated include in the order of their importance, *Quaylea whittieri* Gir.; a species of Eusemion, undescribed; *Tetrastichus blepyri* Ash.; three species of Cheiloneurus; *Eupelmus inyoensis* Ash., determined by Gahan; and *Thysanus niger* Ash. The three under suspicion include one Cheiloneurus, one Eupelmine and a Perissopterus determined by Gahan as *mexicanus* How.[1]

Quaylea whittieri Gir. is by far the most important hyperparasite attacking the Aphycus, in California outnumbering by far all of the others combined. Recovered rarely on *Scutellista* previous to the introduction of *Aphycus lounsburyi*, it sprang into prominence immediately the latter became abundant in the field. The Quaylea became so abundant in some districts that at certain seasons of the year they were noted swarming by the hundreds around the tops of the trees on the ends of the new growth. In one case, from fifty selected scale parasitized by Aphycus, two hundred and thirty-three specimens of Quaylea were dissected and only five Aphycus were found to have escaped attack. In innumerable instances the Quaylea demonstrated their ability to parasitize all of the Aphycus, from two to seventeen, within a single scale.

An undescribed species of Eusemion is second in importance as a parasite of the Aphycus. While occurring throughout Southern California to a greater or less degree it has been particularly abundant in Ventura and Los Angeles counties. *Tetrastichus blepyri* Ash. has also been rather abundant in the two counties mentioned. The other secondaries mentioned have been taken only in limited numbers.

It is worthy of note that the secondaries are most abundant in those areas in which the distribution of the Aphycus was most actively carried on, because of the rapidly increased amount of host material available for their attack. In those areas, this season has seen practically every acre treated mechanically by either fumigation or spraying. The Aphycus, however, has not died out in these districts; it is very much

[1]I am indebted to Mr. Harold Compere, Assistant Entomologist, Beneficial Insect Investigations, University of California, for the above determinations. Mr. Compere is preparing for publication a paper covering these hyperparasites in detail.

in evidence, but it has not been able to maintain itself in controlling numbers.

While conditions have made it practically impossible for the Aphycus alone to control the scale in the "uneven-hatch" areas it has been of unquestioned value as an aid to mechanical treatment. Due to the unevenness of the hatch of the scale, fumigation results are not always satisfactory. If the fumigator waits for the last egg to hatch, those scale which hatched out first often develop to a size immune to such treatment. Aphycus, attacking the adult scale during the period of oviposition, which averages approximately sixty days, has destroyed them before egg laying has been completed. This has a marked tendency to even up the hatch and at the same time advance the date of beginning fumigation operations, thus extending what is ordinarily an altogether too short fumigation period. Scale development is so rapid under coast conditions that many of the Aphycus which escape the fumigation in the pupal stage, are able to bridge the short gap as adults and parasitize those scale which owing to their size escaped the treatment.

Interior or "Even-hatch" Conditions

While the State Department of Agriculture was confining its liberations of the limited amount of Aphycus available for distribution to the coastal areas, the growers in those areas were passing on their enthusiasm to those of the "even-hatch" areas together with a large number of parasites. These were enthusiastically received in spite of the Department's warning of an entirely different field condition to be met and a certainty from the results of early experiments that very little should be expected of them. Evidence of the faith of some growers in the reports which filtered into the newspapers is found in the following short, concise letter received at the State Insectary at Whittier from a grower in one of the farthest inland citrus districts. The letter follows:

"Gentlemen:—

Please send me sufficient Aphycus for eight hundred acres and oblige,

Very truly yours,"

The "even-hatch" areas embrace the interior sections which have a much wider seasonal temperature range and much lower humidity than the coastal sections. By far the greater part of the citrus acreage in Southern California lies within these areas. It was early found that the single uniform generation of scale in these areas limited the period of attack by the Aphycus to approximately two and one-half months in the spring. It is necessary that control be obtained before oviposition by the scale, for the reason that if the scale were allowed to reproduce

itself it would not again be susceptible to attack that season, the Aphycus would largely die out and the new season would begin with as heavy an infestation as the previous one. Strictly speaking the Aphycus would not entirely die out each season, as it has been found that there is always more or less off-stage scale throughout the year on certain of its more succulent host plants, sufficient to carry over a small number of Aphycus from one season to the next.

It has been determined that February 15 is the earliest possible date at which scale of a size suitable to the attack of Aphycus could be found under these conditions. It was thought that if a sufficient number of Aphycus could be liberated at this early date, there would be sufficient time to secure control through the two or possibly three generations which laboratory experiments indicated were possible in the period before the beginning of egg laying by the scale. Field work however soon demonstrated that the prevailing temperatures at that season of the year so retarded the development of the Aphycus, particularly in the pupal stage, that it was practically inactive until after reproduction by the scale had started. One citrus association expended $50,000 this season in an effort to place a sufficient number of parasites in its orchards to offset the short period of effective attack. Though they were able to liberate between five and ten million Aphycus during the spring months, over their properties, they did not succeed in obtaining the desired results. Under these conditions it is obvious that in the "even-hatch" areas the Aphycus can never, by itself, control the black scale. But while this is true, the Aphycus offers other possibilities of value, as in the "uneven-hatch" areas. As a body parasite of the third or "rubber" stage and the ovipositing adult itself, the Aphycus assists in completing a sequence of enemies attacking the black scale, filling a gap between the ladybird, *Rhizobius ventralis*, and *Scutellista cyanea*. This sequence offers a possibility of control under proper handling.

One of the faults of Scutellista has been that almost always it has matured before oviposition by the scale has been completed, with the result that many eggs have escaped destruction and a heavy infestation of scale has followed in spite of an abundance of this parasite. The Aphycus materially increases the efficiency of the Scutellista by attacking the ovipositing adult scale and reducing the period of egg laying, thus making it possible for the Scutellista to consume all of the eggs deposited. That the Aphycus and Scutellista are socially inclined is shown by the frequent finding of both attacking one scale. In one

instance five Aphycus pupae were removed from the body of an adult black scale and three Scutellista pupae were taken from the egg cavity.

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THE SUCCESSFUL INTRODUCTION AND ESTABLISHMENT OF THE LADYBIRD, *SCYMNUS BINAEVATUS* MULSANT, IN CALIFORNIA

By HARRY S. SMITH, *University of California, Citrus Experiment Station*[1]

ABSTRACT

A South African ladybird, *Scymnus binaevatus*, after several unsuccessful attempts, has been colonized on several mealy bugs throughout California. There is a prospect of its becoming of considerable value as a check on these pests.

Mealybugs of several species are among the most important pests of horticulture in California, and up to the present time they have to a large extent proven resistant to all attempts at control by means of fumigation or spraying. This has made them particularly attractive subjects for control by the biological method; several valuable parasites and predators have been introduced into California for this purpose, and very satisfactory practical results have thus been secured.

Among recent introductions is that of the ladybird, *Scymnus binaevatus* Mulsant, from South Africa.

For several years the writer has been in correspondence with Mr. C. W. Mally, Entomologist for the Union of South Africa, at Capetown, with reference to a ladybird existing there, reported to be of importance as an enemy of mealybugs. When Mr. E. W. Rust, parasite collector for the State Department of Agriculture (now for the University of California) was sent to South Africa, he was asked to secure a colony of this ladybird for use in California. This he did and several shipments were made via Australia, but owing to the long journey none of them arrived in a living condition. When Mr. Rust began his return trip to this country in the fall of 1921 he brought a large colony with him

[1]The beneficial insect work was transferred from the California State Dept. of Agriculture to the University of California on July 1. The introduction described in this paper took place before that time.

as far as Sydney, Australia, where, owing to the necessity of making further investigations in that locality, he placed them aboard a steamer for San Francisco. This shipment like its precedessors was unsuccessful, and immediately upon its receipt Mr. Rust was advised of the situation by cable. He had very wisely left a stock in care of Mr. Mally at Capetown and at once cabled him to send another colony to him at Sydney. This was done and by stopping at Honolulu enroute for fresh food for the ladybirds Mr. Rust was able to reach California with 29 living specimens. These were rushed to the Whittier Laboratory where they were given an opportunity to propagate, which they did so effectively that within a year approximately 250,000 were colonized throughout the state.

Mr. Rust writes as follows with reference to this species:

"In South Africa it is quite commonly encountered and does much beneficial work against various mealybugs, but in its native home it is preyed upon by a parasite which often decimates it, and so keeps it from being as effective a check on its host as would otherwise be the case. This parasite (*Homalotylus africanus* Timb.) gave a great deal of trouble in the insectary at Capetown while material was being reared for shipment to California and it was only by exercising a good deal of patience that the parasite was finally eliminated and a good clean stock of ladybirds built up for shipment. However, this was finally accomplished and the coccinellids were brought to California without their parasite, so here they should increase very rapidly, being free of their hereditary foe."

Scymnus binaevatus is very distinct in appearance from any California species of the genus because of its greatly elongated body. It is blackish in color with a brown spot on each elytron. The larvae are very similar to those of other species of Scymnus, being covered with a white, waxen secretion. This ladybird has the habit of seeking crevices in bark and other hidden places for feeding, a habit which is of especial value in the case of certain mealybugs which would otherwise escape its attack.

This ladybird has been colonized throughout the state, on *Pseudococcus citri*, *P. gahani* and *P. maritimus*. Besides southern California colonies, it has been liberated in the counties of Tulare, Fresno, Kings, San Joaquin and Alameda in northern California. The first field liberation was made in March, 1922. It has since been recovered in the orchards in abundance at Santa Monica, Pasadena, Alhambra, Oxnard, Rivera and San Fernando. As many as 50 adults have been found in a single burlap band. Recoveries so far have been made only in orchards

infested with citrophilus mealybug, but insufficient search has been made in case of other infestations to justify any conclusion that it will not attack the other species. It is believed that this ladybird will become of considerable value in the control of the above mentioned species when it has had sufficient time to become thoroughly established.

Through the courtesy of Dr. L. O. Howard, specimens of this ladybird were studied by Mr. E. A. Schwarz of the National Museum, who reported as follows:

"The small Scymnus from South Africa is most probably identical with *Scymnus binaevatus* Mulsant (1850), described (apparently from a single specimen) from "la Cafrerie." The type is now in the Stockholm Museum. Mulsant's description agrees very well with Mr. Smith's specimens but it is not known to me at present whether or not other African species of Scymnus allied to *S. binaevatus* have been described by recent authors. It would be safe, therefore, to refer to the species as "*Scymnus (Sidis) binaevatus Muls.?*".

THE HISTORY OF HYDROCYANIC ACID GAS FUMIGATION AS AN INDEX TO PROGRESS IN ECONOMIC ENTOMOLOGY

By R. S. Woglum, *Entomologist, California Fruit Growers Exchange, Los Angeles, California*

Abstract

Hydrocyanic acid gas fumigation was discovered in 1886. From 1886–1893 it underwent decided improvement as a fumigant for citrus trees; 1893–1900, greenhouse, nursery stock, stored products and mill fumigation were introduced; 1907–08, orchard fumigation was standardized; 1910–13, sodium cyanide displaced potassium cyanide; 1912, portable machine generator invented; 1913–14, vacuum fumigation developed; 1916, liquid hydrocyanic acid first used for fumigating; 1923, calcium cyanide dust experimented with as fumigant.

The ascendency of American economic entomology during the last half of the 19th century appears attributable primarily to the development of methods which offered noteworthy relief to agriculturists suffering from insect depredations. The maintenance of this supremacy in pest control has rested largely on the discovery of new or the improvement of old methods or practices. The history of hydrocyanic acid gas fumigation during its thirty-seven years of use is peculiarly illustrative of entomological progress. It appears a fitting topic at this meeting as its discovery in 1886 by Coquillett was made in Los Angeles, the first experiments being conducted in the famous Wolfskill Orchard, now displaced by the Southern Pacific Station. Much of the later progress in fumigation has also been made in Southern California.

Coquillett's discovery was the outgrowth of unsuccessful efforts to

control the cottony cushion scale with sprays. In its earliest stages, the gas process was interesting rather than fully practical. The tents were bell-shaped, very heavy, sometimes oiled, and almost gas tight. Very cumbersome equipment was used to move these tents over trees. The process was slow and necessarily expensive. The generation process of concentrated acid slowly dropping onto dry cyanid, or into a cyanide solution was prolonged and somewhat uncertain of uniformity.

By the early nineties, fumigation had undergone vast improvement. The heavy bell-shaped tents had given way to flat octagonal sheets of untreated tightly woven canvas. The advent of flat sheets which could be moved by two poles greatly simplified the covering and reduced the cost of the operation. The simple pot method of generation, which consisted of dropping solid cyanide into a dilute acid had come into use. Day fumigation had given way to night fumigation, which meant less plant injury. The greatest weakness of the system at that time was the lack of an accurate and practicable method of estimating the dosage, and this condition was reflected in one way or another throughout the first 20 years of orchard fumigation, at times receiving no small amount of attention from California investigators, particularly Woodworth. Nevertheless, the system as a whole proved sufficiently satisfactory that it rapidly became the standard of scale-insect control in California, a position maintained up to the present time. From 1893 to 1907, there was no outstanding development in orchard fumigation other than in increased volume of work done. Conflicting ideas between fumigators on dosage, exposure, proportion of chemicals and general procedure, however, became numerous.

The last fifteen years have seen the greatest progress made and the most rapid changes in fumigation since its earliest days. The development by Morrill in 1907 of a practical method of marking tents for the calculation of dosage was the most important step toward accurate orchard fumigation. The writer introduced this marked tent method of fumigation into California in 1908, strengthening it by a dosage schedule adapted to the fumigation of any citrus tree pest against which fumigation is practiced. The superiority of the marked tent system with its sliding scale of dosages rapidly became apparent to growers and fumigators alike and for the last decade has completely supplanted all other methods wherever orchard fumigation is practiced.

Potassium cyanide exclusively was used in fumigating up to 1909. The work in 1908–09 of Woglum and McDonnell showing the availability of high grade sodium cyanide for fumigation formed the basis of con-

version from a potassium to a sodium basis in 1910–1913 when the price of potash products increased. Since 1914, sodium cyanide has dominated the field in all lines of fumigation.

In 1912, William Dingle, a practical fumigator, invented a portable machine for generating gas outside the tent from cyanide in solution. Subsequently a modified type of generating machine known as the cyanofumer was developed in Los Angeles and displaced the pot system very largely in California in 1915–17. Although this new method did not appear superior to the pot method in scale control, it was an improvement in several ways over the more cumbersome pot method from the standpoint of the fumigation manager.

One of the greatest forward steps in fumigation was the development of liquid hydrocyanic acid by William Dingle in 1916. Mally, in South Africa was experimenting in a small way with the same chemical almost simultaneously but entirely independently. The simplicity of the "liquid gas" method, as commonly termed, led to its immediate adoption in California. A combined attack on the problem by entomologists, chemists, manufacturers and fumigators quickly led to the development of a standardized system of liquid gas fumigation with a uniformly high grade product. Today fully 90 per cent of the 2½ million dollar annual fumigation campaign in California comes under the liquid system, the remaining 10 per cent being divided between cyanofumer and pots. Three large manufacturing concerns are now in the field, one making the liquefied product from sodium cyanide, one from calcium cyanide and the other synthetically.

Methods of application have undergone repeated changes and no less than 12 different types of generating machines have been developed and used since the method originated. Some of these machines have been adapted for atomization of the liquid through a mist nozzle while others convert the liquid to gas by heat. A very large amount of valuable data bearing on the limitations of liquid hydrocyanic acid for orchard fumigations has been accumulated. One reflection of this information is the greatly increased practice of daylight fumigation, a decidedly hazardous operation in former days with pot or cyanofumer.

The most recent development in fumigation has been the use of calcium cyanide as a dust. Quayle was the first to use this material for fumigating beneath a tent. At the present time calcium cyanide dust as an orchard fumigant is merely in the experimental stage. Preliminary work appears to have shown it very effective against scale insects but more damaging to plants under certain conditions than cyanide gas

generated after the other methods commonly used. If this injury factor is neutralized, there is likely to be a further change in the orchard fumigation practice. Calcium cyanide has also been tried out as a dust on various plants. Flint, in Illinois, has done considerable work with it against the Chinch Bug. In California, it is being tried against various pests.

My discussion has been confined to a statement of progress largely as illustrating orchard fumigation. There has been great development in hydrocyanic acid gas fumigation along various other lines. Between 1893 and 1900, cyanide gas was successfully used in treating greenhouses, nursery stock, stored products, mills and other buildings. Each of these methods has experienced great improvement and wider application in recent years. No attempt will be made to detail this progress. More recently railway cars and ships have been fumigated successfully.

The development in 1913–1914 of vacuum fumigation by Sasscer and Hawkins opened an entirely new and highly important field. Vacuum fumigation at once supplied a method of destroying insects in products which no other system of fumigation is able to reach successfully. It has been found to be the system of fumigation under which insect eradication is most certain. Its value in plant quarantine is attested by the number of large vacuum plants at American ports of entry for the treatment of foreign products which might contain insect pests. In California a number of small plants have been installed for treating nursery stock, stored products, et cetera. Vacuum fumigation is assured a great future and its development is proceeding rapidly, especially under the guidance of the Federal Horticultural Board. In California, Mackie of the State Department of Agriculture has made decided progress in the treatment of nursery stock and stored products.

The environment of insects, as well as of plants, at the time of fumigation has a decided influence on efficiency in insect destruction as well as injury to the plant. Valuable data bearing on the influence of various factors, such as wind, temperature, moisture, sunlight, Bordeaux mixture, physiological condition of the plant, have been and are being developed by entomologists and others, thereby increasing the certainty of insect destruction and reducing the hazard to the plant.

THE WHITE SNAIL (*HELIX PISANA*) AT LA JOLLA, CALIFORNIA

By A. J. Basinger, *University of California,*[1] *Citrus Experiment Station*

Abstract

Helix pisana, a European snail, became established in California and measures were taken to eradicate it. In Europe this snail is a pest of citrus trees. Observations at La Jolla, California, verified this. It is also a possible pest among other cultivated plants. The average number of eggs per individual at La Jolla in December 1922, was 120. This is higher than the number given for Europe. The methods employed in eradication were; clearing the ground of vegetation, flaming the cleared areas, use of poison bait of calcium arsenate and bran, and hand-picking. The results were effective and very few *Helix pisana* are left after one year of eradication work.

The white snail (*Helix pisana*) is a European species, native in Sicily and of considerable economic importance in that country as a pest of orange and lemon trees. The fact that this snail had gained a foothold at La Jolla, San Diego County, California was first brought to the attention of California horticultural officials by Dr. L. O. Howard in 1918. Eradication measures were undertaken at that time which resulted in almost complete extermination (1). Inability, however, to keep up the fight against the snails resulted within a few years in an infestation of such magnitude that there was grave danger of the white snail spreading to the citrus areas of California. The Bureau of Pest Control of the California State Department of Agriculture and the San Diego County Horticultural office, in consultation with the U. S. Department of Agriculture then formulated a cooperative campaign to eradicate the pest. Active operations were commenced on July 17, 1922.

Economic Status of Helix Pisana

The economic importance of *Helix pisana* in Europe is given by T. de Stefani (2). He says that the snails feed on the foliage, bark, tender twigs, fruit and blossoms of orange and lemon trees, and on the foliage of almond and olive trees. In La Jolla *pisana* was observed to feed on a great variety of plants, including a small grapefruit tree that was seriously impaired by constant defoliation. In another instance a clump of zinnias in a flower garden made no progress until the snails were destroyed on the premises. The fact that *Helix pisana* feeds voraciously on a variety of plants indicates that it may be a possible pest of crops other than citrus. I have no doubt that it would prove quite damaging to vegetable crops and small fruits as I found it to be fond of the leaves of sweet potatoes, chard, beets and blackberries.

As a nuisance this snail has first rank about a home because it occurs in enormous numbers where conditions are favorable and crawls on and

[1]This paper records the results of work undertaken while the writer was in the employ of the California State Department of Agriculture.

into everything. In La Jolla they became so numerous in places that during the rainy season while the snails were crawling about one could hardly travel on the sidewalk without crunching snails at almost every step.

The Infestation at La Jolla

It is not know how or when *Helix pisana* was first introduced into the United States but one rumor credits a European resident of La Jolla with its introduction for the purposes of a table delicacy. This snail is used extensively as an article of food in France and Italy. It may have escaped from among a collector's specimens, for if taken while sealed with a heavy epiphragm it appears quite lifeless and may, after months, push off the seal and crawl about again. The earliest record of its existence in La Jolla is from some specimens in a collection of shells marked "La Jolla, June, 1914."

When first brought to the attention of the San Diego County Horticultural Office in 1918 the infestation was in the lower end of a canyon that runs through the southern portion of the town, and in a few of the adjoining lots. It covered at that time an area of about three or four city blocks (1). In 1922 the snails had spread throughout the whole length of the canyon and the adjoining properties. They were in twenty-two different city blocks and had a good start also at the Scripps Institution for Biological Research which is about two miles north of La Jolla. In the eradication work it was necessary to treat about eighty acres. This included a margin of safety beyond the actual infestation.

Throughout a large part of the infested area the white snails were present in astonishing numbers. They were on virtually everything—houses, fences, bridges, curbings, trees, telephone poles, shrubbery, weeds and rock piles. In the summer they were sealed fast to the various objects waiting for the rainy season. Only in places that received water regularly was there any action among the white snails in the dry summer. McLean (1) counted 798 snails on a small wild buckwheat bush less than two feet across. In a garden plot 16 by 19½ feet we took out 6690 snails. This was about 21 per square foot and represented a fair average for much of the infested area.

Life History and Habits

Helix pisana is a member of the Pulmonata, a group which comprises the air-breathing Gasteropods. The typical shell is light buff with lineal brown stripes. The variation in shell color ranges, however, from white to buff with no marking of any kind to those having as many as fourteen lineal brown stripes. The usual size of the adult shell is one-half

to three-fourths inch in greatest diameter. The body is light cream to dark gray and in the adult has an extension of one and a half to two inches. As there is no operculum the aperture is sealed with a temporary epiphragm during drought or other unfavorable conditions.

This snail is hermaphroditic and mutual fertilization is necessary for reproduction. Mating begins in the fall when the first rains come and oviposition follows from a few days to several weeks later. At La Jolla mating under natural conditions was first observed November 9 after a good rain had fallen during the night. The first snails were found ovipositing on November 30 after several days of wet weather. When ready to lay eggs the snail digs a hole in the ground about one and a half inches deep and enlarges the lower end to form a cavity for the egg mass. As the genital aperture is at the anterior end the snail does not withdraw its body from the hole until the entire process of digging and egg laying is finished. The soil is dug loose by the lips and jaw and worked out along the lower side of the foot in a flat ribbon onto a little conical pile to one side of the shell. The eggs are deposited singly but adhere to each other as they emerge, forming a mass that looks much like a white blackberry. They are spherical, about two millimeters in diameter and milky white. When through laying eggs the snail withdraws from the hole and carefully closes it at the top with mucus and bits of soil, and then crawls away. The whole process requires several hours. According to T. de Stefani (2) each adult oviposits but once in a season; however, as the generations overlap, egg laying continues from the beginning of wet weather in the fall to the dry season in the spring. He gives the number of eggs deposited by a single individual as from fifty to seventy. At La Jolla in December 1922 the number of eggs in twelve egg-masses ranged from fifty-two to two hundred and twenty-six. The average was one hundred twenty. The number of eggs would no doubt vary according to the age and size of the snail and perhaps also with weather conditions.

The time of hatching, of course, depends on favorable temperature and moisture. In Europe T. de Stefani says it is twelve to sixteen days. At La Jolla it was about three weeks. Eggs laid on the last of November hatched about December 20. The newly hatched snails have a very thin shell of one and a half whorls. The adult snail has five whorls and a fairly hard shell. Shortly after hatching the young begin to feed on the tender plant growth in the vicinity of the nest. Of the snails hatched on December 20 the largest one was about three-eighths of an inch across at the end of fourteen weeks. Besides feeding on nearly all kinds of

green vegetation they also eat such materials as weathered wood, paper and earth.

METHODS OF ERADICATION

In eradication work against this pest the first step taken was to clear off all the vegetation, excepting trees, in the canyon and open lots throughout the infested area. Heavy eye hoes were used for this purpose and everything was cut down to the bare ground. It was then worked into piles or windrows where it was left to dry for several days before burning. Leaving the ground bare made an extremely unfavorable condition for the snails, as it reached an uncomfortable temperature during the heat of the day. The disturbance caused by the hoeing stirred the snails into action and many took refuge in the windrows where they were later burned.

Following the clearing of the open areas they were next burned over by a flamer. The outfit for this work consisted of a power sprayer with distillate as the fuel. Nozzles producing a fine spray were mounted on 16-foot iron rods. The distillate was forced through the nozzles and the spray set on fire. The effect was that of an immense blow torch. The flame was played over the ground leaving in its wake a black, barren waste. Of course, some snails under stones and in crevices and other protected places escaped the direct flame and were not killed. However, they were easily picked up later by hand as the disturbance caused them to crawl about and they could be readily located by their slimy trails on the black ground. Two line of hose each seventy-five feet long were operated from the spray rig. This was necessary in order to reach the remote parts of the canyon. Several times it was necessary to join the 75-foot lengths into one in order to flame distant parts.

While the open properties were being cleared and flamed we were carrying on a series of experiments to determine the best means for eradicating the snails from about the many dwellings where we had to deal with lawns, flowers, shrubbery, trees and vegetables. We had no intention of applying the devegetating and flaming process about these places except, possibly, as a last resort. Fortunately our efforts were successful, for in the use of calcium arsenate and bran as a bait we found one of the most effective measures in the fight against *Helix pisana*. This poison bait was adapted from Lovett and Black (3), who used calcium arsenate and chopped lettuce leaves as a control for the gray garden slug in Oregon. We used it in the proportion of one part of calcium arsenate to sixteen parts of bran. It was first mixed dry and then water added until a moist but not wet mash was obtained. Nothing

else was added. It was scattered over the infested area as in sowing grain. Before the winter rains came we were able to get the snails into action by sprinkling the treated areas with garden hose. The snails fed readily under these conditions. During the rainy season the entire infested area was treated twice with the poison, once in the fall and once in the spring. In our trial plot, which consisted of a garden 16 by 19½ feet, we secured in six days a kill of 92.46% of all snails present. There were 6,690 snails in the plot but of this number 259 were still sealed up. This gave us a kill of over 96% of all active snails. The results in our practical applications were fully as satisfactory. It might be well to state here that the brown snail (*Helix aspersa*) also feeds readily on this bait and the poison is highly recommended for that pest.

In spite of the apparent thoroughness with which the clearing, burning, and poisoning were done, it was still necessary to supplement by hand-picking in order to get the few that persisted in remaining sealed up. Hand-picking also had to be resorted to in getting the snails from underneath buildings, from fences, bridges, and other places where we could not use fire or poison.

Progress of the Eradication Campaign

The progress of the eradication campaign at the end of the first year has been such that even the careful observer in La Jolla no longer sees a white snail. A year ago there were millions of them and people came from neighboring towns to see them clustered in great masses on the weeds and shrubbery in the infested area. In the last ten weeks four live white snails have been found by inspectors from the San Diego County Horticultural Office. While the progress has been more than we thought possible in a year it no doubt will take several years of frequent and careful inspections and treatment before the white snail is entirely stamped out at La Jolla.

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Chairman R. E. Campbell: Two papers have been submitted by members who could not be present and will be read by title as follows:

BEES VS. SPRAYING

By R. W. DOANE, *Stanford University*

Much has been said and much written on the subject of bees being poisoned when near-by trees were sprayed while in blossom. Most of these complaints come from the bee-men, themselves, and investigations have sometimes shown that the death of the bees was due to other causes. Several articles written by entomologists and others have, when analyzed, been found to be based entirely on reports made by beekeepers. But Bulletin 247 of the Purdue University Agricultural Experiment Station, published in 1920, contains an interesting account of very definite experiments conducted by W. A. Price, to determine whether the bees could be affected in this way and to determine the amount of arsenic necessary to kill a bee.

Because the results he obtained in these experiments were so very different from a series that I conducted about the same time and in somewhat the same way, it may be of some interest to record the results of my observations.

On April 15, 1919, I sprayed an apple tree that was almost in full bloom with arsenate of lead, using 3 lbs. of the arsenate of lead to 50 gals. of water and using 8 gallons of this spray to the tree. The spray was applied with a pressure of from 150 to 200 lbs., especial effort being made to fill the calyx cups as far as possible. The tree was then covered with a cabinet made of a light wood frame that was covered with a good quality of gauze. In order that there might be sufficient room on each side of the tree the cover was made 18 x 18 x 16 ft. high. The cloth, while fairly firm was light enough so that the activities of the bees inclosed therein, would not be interfered with.

On April 17, in the evening, a moderately strong colony of bees was placed beside the tree under the cover. On the morning of April 18, 2 gallons more of the spray was applied to the tree. This time the spray was applied as a very fine mist, the leaves and petals being well covered in this way. The screen that closed the hive was then removed and the bees were allowed to fly around inside the cover. Within a short time some of them were visiting the blossoms, apparently feeding; before noon scores of them were feeding freely. A number of the bees flew directly to the top of the cabinet and tried to escape and during the whole course of the experiment some bees were to be seen along the upper corners trying to get out. On the morning of the 19th the bees that had remained outside of the hive over night were chilled and not able to fly. Some of them had dropped to the ground and were crawling

about feebly, but very few dead ones were found. During that day and the following day the bees were watched carefully and their activities seemed to be perfectly normal. At the end of the second day the bees were taken back to the apiary from whence they came. About 125 dead bees were found inside the cabinet and 65 live bees that had not found their way back to the hive, were also collected. These were placed in separate vials to be submitted to a chemist for analysis to determine whether they would show any traces of arsenic.

On the afternoon of April 21 with the owner of the bees, I made an examination of the colony that had been returned to the apiary. We found them working in an apparently normal way and we found that they had been storing honey during the two days that they were in the cabinet. All of the larvae seemed to be in normal condition; a number of cells were open and it is to be presumed that the larvae were being fed during the time of the experiment, otherwise they would have died. The queen had been laying eggs, and there was nothing about the colony to suggest any unusual conditions. I may add here that this colony was observed from time to time during the following year and no unusual conditions were noted.

On April 22, in order to check the first experiment the cabinet was placed over another tree near the one that had been sprayed for the first experiment. This tree was about the same size and shape and in about the same condition as regards blossoming as the tree used in the experiment. We then selected another colony of bees that corresponded as nearly as possible in every way to the colony that had been placed under the cabinet in the first experiment. This colony was placed under the cabinet with the tree that had not been sprayed and their behavior carefully noted. The first ones that came out flew about uneasily for awhile, many of them flying to the top of the cover where some of them stayed. Many of them soon began to feed on the blossoms and in a short time they were feeding in a perfectly normal way. In the evening it was noted that a number were still clinging to the top of the cover, a few were found dead on the ground, and a few were crawling about in the grass. There was some brown spotting on the top of the hive and on a strip of cardboard placed on the ground in front of the hive; similar spots to these were seen during the progress of the first experiment, and there seems to be nothing abnormal about these spots. The number we found is doubtless due to the fact that the bees could not fly far away and any droppings from them would, therefore, be more numerous in the inclosed space and so more conspicuous.

The bees were under observation until noon the next day. During this time the bees in this check experiment behaved in the same way as the bees that were used in the first experiment. All the dead bees that could be found were then gathered up and placed in a vial in order that they might be submitted to the chemist for analysis, to check the analysis made on the bees taken from the cabinet when it was over the tree that had been sprayed.

When the chemist submitted his report after he had analyzed these bees, it was found that the dead bees that were collected in the cabinet at the end of the first experiment, contained .00000255 grams of arsenic per bee. The bees that were collected while they were still alive during the first experiment, showed .000002 grams per bee. The bees that were found dead in the cabinet when it was used for the check, contained .0000006 grams of arsenic per bee.

In making these tests the bees were counted and weighed and then placed in beakers and digested with nitric acid followed by sulphuric acid. The arsenic was then determined by the well known Gutzeit method, a blank on the chemicals was run with the samples.

These analyses showed that the difference between the content of arsenic in the bees that were exposed to the arsenic and those that were not exposed, was so minute as to be inconsiderable.

It must be remembered that all plant and animal substances contain quantities of arsenic, so that careful analysis made at any time will always show a trace.

In the spring of 1920 I began another series of experiments in which I sprayed the trees while they were in full bloom in order that I might test the effect of such a spraying on bees and thus check up the experiments conducted in 1919. On April 12, 1920, two apple trees were sprayed with arsenate of lead, using 6 lbs. of arsenate of lead to 50 gals. of water. About 5 gallons of the spray was applied to each tree and care was taken to drive the spray into the calyx cups as much as possible. As there was a little mildew on these trees some atomic sulphur was used in the spray. Many of the blossoms on one of the trees were gone; the other tree had at least half of the blossoms on it and a number of bees were visiting the blossoms evidently feeding. In another part of the yard a pear tree, which was in full bloom, was sprayed with the same material. As this was a small tree all of the blossoms were easily available and it was given a good thorough spraying.

On an adjoining lot was a hive of bees, situated about 25 ft. from the

pear tree and about 100 ft. from the apple trees that were sprayed. The bees that were feeding on the trees at the time the spraying was done were passing to and fro from this hive. On April 19 the same trees were sprayed again; on this day I used dry acid arsenate of lead at the rate of 4 lbs. to 50 gals. of water, and added to this dry Bordeaux mixture, using the latter at the rate of 6 lbs. to 50 gals. of water. There were still a few blossoms on one of the apple trees and many on the pear tree. During the interval between April 12 and 19 I had an opportunity to watch the bees as they were coming from and returning to the hive on the lot near the sprayed trees. As far as I could determine they were in normal condition.

On April 17 I placed a hive with a fairly strong colony of bees in it, under one of the apple trees on an adjoining lot where there were five or six apple trees blooming. The hive was kept closed for 24 hours and when it was opened in the evening a great many bees came flying out but within an hour most of them had reentered the hive or had settled on it close to the entrance. The next day a number of dead bees were found on the canvas that was spread in front of the hive. These were all brushed away; I found later that some dead bees were still being carried out; these bees had doubtless died because the hive was closed for such a long time. On April 19 I selected two of the trees that were closest to the hive and gave them a very thorough spraying with arsenate of lead, using 6 lbs. of arsenate of lead to 50 gals. of water, and applying 5 gallons of the spray to each tree. These trees were in full bloom, a few of the petals were just beginning to fall. Care was taken to drive the spray into the calyx cups as much as possible. A third tree which was much larger and which was just coming into full bloom, was sprayed with dry acid arsenate of lead, using 4 lbs. of the arsenate of lead to 50 gals. of water. About half of this tree was sprayed with the coarse spray, an attempt being made to drive the spray into the calyx cup as usual. The other half was sprayed with a fine mist, an attempt being made to cover all of the blossoms and the leaves with this fine mist. The spraying was continued until it appeared that the leaves were covered with all of the material they would hold without dripping.

When I began spraying, the bees from the hive were feeding on the blossoms in great numbers; most of them were driven away by spray material but within ten minutes of the time the spraying was stopped, a number of them were back on the tree again, so their feeding was interrupted for only a short period. The day was sunny and fairly warm although a slight breeze was blowing intermittently. This work was

done with a small hand-power spray pump and a pressure of 150 to 175 lbs. was maintained. During the next ten days I watched the bees and the trees very carefully and then took the colony back to the apiary from whence it came. During the time that the bees were in the orchard no unusual conditions developed. The bees had been working actively and while a few dead bees had from time to time been found on the cloth spread outside of the hive, the number had not been more than one would expect to find around a hive at this time of the year. An examination of the hive at intervals after it was returned to the apiary showed that the bees and the brood were in good condition and that the bees had stored a good deal of honey during the time they fed in the small apple orchard.

It is a common practice among the bee men of Santa Clara Valley to lease their bees to orchardists for the blossom period, some orchardists paying as high as $2.00 or even $3.00 a colony to have the hives placed in various parts of their orchards. No restrictions are made as regards spraying and it is a well known fact that California orchardists are enthusiastic sprayers. One prominent bee-man told me that when he first began this practice of renting his bees for use in the orchards he feared that he might lose some of them when the trees were being sprayed as he had heard that bees were sometimes poisoned in this way. But as year after year went by and he noted no bad results from having his bees in orchards where they were spraying with arsenical and other sprays, he came to pay no attention to it at all.

In the Pajaro Valley, one of our important apple-growing sections, the orchardists begin to spray very soon after the apple blossoms appear and continue to spray for several weeks so the bees have every opportunity to feed on sprayed blossoms over a long period, yet we do not have any reports of spray injury to bees in that section.

A real California booster would say "It's the climate!" Possibly it is.

SOME ASPECTS OF BIOLOGICAL CONTROL IN HAWAII

By D. T. Fullaway, *Entomologist, Hawaiian Board of Agriculture and Forestry*

The use of natural agencies for keeping insect multiplication within bounds, which the term "biological control" connotes, has proved a most successful method of dealing with injurious insects in the Hawaiian Islands, and has been of great economic value. Artificial methods of control, on the other hand, have given generally poor results. The reason of this is found in peculiar conditions here, which I shall attempt to describe.

Nearly all of our pests are immigrant species, and many of them have become established in Hawaii without the checks upon their multiplication which exist in the lands from whence they came. The climate here also is conducive to the rapid multiplication of insects. The temperature rarely falls below 60 degrees Fahrenheit in the lowlands. Hence, it is possible for the development of insects to go on without interruption, and six to eight cycles annually is not unusual for many species. Hibernation phenomena are scarcely discernible. Again, a luxuriant vegetable growth furnishes an ample supply of good.

In these circumstances, adaptable species reach excessive numbers in a very short time, occupy the land to the extent of available food, and generally become a scourge on improved land. Artificial methods of control are inadequate to the situation, usually not giving the desired results and involving excessive expenditure to get even poor results.

On the other hand, all the conditions cited as favorable to the excessive multiplication and rapid dissemination of injurious forms, likewise favor the use of natural agencies for their restraint. The introduction of beneficial insects can be undertaken at any time of the year, their propagation and colonization are greatly facilitated by the abundance of host material and the absence of a dormant season, which in more northern latitudes often seriously hampers biological work. The peculiar nature of our insular fauna is also a favorable circumstance here, the paucity of forms operating to make the incidence of hyperparasitism less likely.

Finally, the character of our agriculture is also a favorable circumstance. I mean to say that the bulk of our production is limited to a comparatively few crops, grown under field conditions over large areas, and the business of production is highly organized. These features all work advantageously. In the first place, the limited scope of the work makes it a possibility as far as the time element is concerned. Secondly, centralized management and adequate support are essential to expensive work involving a high degree of technical skill and sustained effort. Thirdly, the effect of a small improvement is rendered disproportionately great when the application of it is extensive.

In stating that our work along the lines of biological control has been successful, I do not wish to be understood to imply that the success has been uniform in degree or that the establishment of a beneficial species has succeeded from every introduction made. Quite the contrary has been the case. The consignments received from our collectors which have produced results are few in number when compared with the total

number of consignments made, and the results have varied to a very high degree, from the perfectly satisfactory control of *Anomala orientalis*, achieved through the introduction and establishment of a single enemy, *Scolia manilae*, to the fruitless search for wire worm enemies, which has extended over four years. An entirely satisfactory control of the sugar cane leaf hopper has only been achieved after twenty years' work, involving the introduction of more than a score of enemies. The control of the Mediterranean fruit fly has not been entirely satisfactory owing to the fact that the larvae occur in many fruits with a thick pulp, where the parasites which are effective to a high degree in thin-pulped fruits, cannot reach them. Recent introductions to improve the control of the avocado mealy bug, *Pseudococcus nipae*, have given marvellous results in a very short time, but in the case of other coccid species the control exerted by parasites and predators has been less marked.

A perplexing question in our experience with this work has been, Should all the obtainable enemies of an injurious species be introduced or should a complex be avoided and dependence put upon one effective enemy. I believe this, in the light of our experience, is still a debatable question.

I realize that in this hasty survey of the subject I have only skimmed its surface, but I have been warned of a time limit. In conclusion I would add that if the application of this method to the subjugation of an insect pest does not always result in a full and complete control of the pest, it at least often brings its multiplication within such bounds that artificial methods can be used with some degree of satisfaction. Also, that the main defect of the method from a practical standpoint appears to be its limited application.

Afternoon Session, September 19, 1923

R. E. Campbell, *Chairman*

JOINT MEETING WITH ECOLOGISTS, PLANT PATHOLOGISTS AND PLANT PHYSIOLOGISTS

Subject: Ecological Factors Influencing Distribution and Severity of Insect Pests and Plant Diseases.

Papers were presented by H. S. Fawcett and E. T. Bartholomew, and afterwards discussed by the members present.

A telegram was sent to the members whose homes were burned in the Berkeley fire and included W. B. Herms, H. H. P. Severin and Dr. E. C. Van Dyke, all of the Entomology Division, University of California.

The meeting was adjourned to meet next year with the Pacific Division of the American Association of Economic Entomologists at the place to be announced later.

A SIMPLIFIED METHOD FOR MAKING LUBRICATING OIL EMULSIONS[1]

By A. M. Burroughs and W. M. Grube, *University of Missouri, Columbia, Missouri*

Abstract

A method is described by which stock emulsions of paraffin oils used in spraying are made without heat and without the use of potash fish-oil soap. Freshly made bordeaux mixture or copperas-lime mixture, calcium caseinate, saponin and other substances were used as emulsifying agents in the place of soap. The oil, water and emulsifying agent were placed together in a container and pumped twice under fairly high pressure. The emulsions made in this way were used successfully on a large scale. They gave as good results against San Jose scale as the emulsions made with potash fish-oil soap, and were cheaper and easier to prepare. These emulsions did not break down in the presence of hard water or water contaminated with lime or lime-sulphur.

In the past few years there has been a marked increase in injury to apple trees from San Jose Scale in northern Arkansas, southern Missouri, and southern Illinois. The standard dormant spray of strong lime-sulfur solution has failed to give control in some cases. In an effort to control scale more cheaply and efficiently, the Bureau of Entomology of the United States Department of Agriculture tried out the lubricating oil emulsions used against citrus scale in Florida. Experiments carried out by Ackermann[2] at Bentonville, Arkansas, in 1921–22, indicated that a 2% emulsion of engine oil was effective against San Jose Scale on apple trees. As a result of his work, a large number of orchards in Arkansas, Missouri, and Illinois have received dormant applications of this spray during the spring of 1923.

The formula and methods for preparing the emulsion are given by Yothers[3] and Quaintance.[2] This is generally known as the "Government Formula" and is given below:—

Engine Oil	2 gal.
Potash Fishoil Soap	2 lbs.
Water	1 gal.

The oil and the solution of soap in the water are mixed and heated to the boiling point, and pumped twice through a pump giving 60 lbs. pressure. Further directions and details are given in the publications referred to above. This method has given good results at the Missouri

[1]Contribution from the Departments of Horticulture and Entomology, University of Missouri. The authors wish to express their appreciation of the advice and help received from the members of these two departments, and especially from Mr. O. C. McBride of the Dept. of Entomology.

[2]U. S. Dept. of Agriculture Clip Sheet 193, 1922.

[3]U. S. Dept. Agriculture Farmers Bulletin 933, 1918.

Experiment Station, and has been successfully used by many growers in the State. Other growers have had trouble in getting good emulsions. Emulsions made according to the Government Formula have been put on the market by spray companies, and in some cases the growers have been advised to buy these rather than make their own.

It has been stated that the oil-soap stock emulsion made according to the Government Formula contains $66\frac{2}{3}\%$ oil. This is not the case. To make stock emulsions containing $66\frac{2}{3}\%$ oil by volume, the following formula has been used here:—

Engine Oil	2 gal.
Potash Fishoil Soap	2 lbs. (about 1 qt.)
Water to make total of	3 gal. (about 3 qt.)

We have been able to make good emulsions using 1½ lb. of soap instead of 2 lbs. as in the above formula. These stock emulsions of oil and soap, containing 59–67% oil, mix freely with soft water, and are added to a tank of water in proper proportions. However, if mixed with hard water, lime-sulphur, or any mixture containing an appreciable number of calcium ions, spontaneous de-emulsification occurs. This is due to a reaction between calcium and the potassium soap, with the formation of a calcium soap. A calcium soap tends to stabilize emulsions of water in oil, rather than of oil in water. Under working conditions, however, de-emulsification occurs rather than a change of phase. Oil-soap emulsions can be "stabilized" for use with hard water and lime-sulphur, by the addition of glue, casein, flour, starch, etc.[3] A ½-½-50 Bordeaux mixture has been widely utilzed as a stabilizer when hard water has to be used.

Following the work of Pickering,[4] emulsions have been made up at the Missouri Agricultural Experiment Station in the cold, using Bordeaux mixture, and a mixture of ferrous sulphate and lime as emulsifying agents. Calcium caseinate, sold under the trade name of "Kayso" has also been used successfully as an emulsifying agent, as well as powdered saponin and extract of soap bark. Such emulsions have been made up in considerable quantity, and used in spraying over 300 bearing trees. No statement can be made in this article as to the expediency of replacing lime-sulphur by oil emulsions for the dormant spray. However, the success attained in preparing and applying these emulsions, it is believed, warrants the presentation of the method of preparation. A comparison of the results obtained with such emulsions and those made according to the Government Formula is also given.

[4]Journal Chemical Soc. 91: 2001, 1907.

The engine oils used in Florida are residual oils, with a specific gravity of around .90. They boil between 300° C. and 400° C. The brands of oil used in this work were "Paraffin Diamond" and "Red Engine Oil," purchased from the Standard Oil Company of Missouri. Paraffin Diamond is the type of oil used in oiling floors. Red Engine is somewhat heavier, and is used as a cheap, low quality lubricant. When using what he called finely divided solids as emulsifying agents, Pickering used "solar distillate "a residual oil boiling between 240° C, and 350° C, and having a specific gravity of .858. In many respects this resembled the paraffin oils used recently in the United States.

In Pickering's work, Bordeaux mixture, or ferrous sulphate-lime mixture was made up according to the Woburn formula; that is, with no excess lime present. The desired percentage of oil was added directly and the mixture emulsified by pumping it back on itself by means of a "garden syringe." We have made stock emulsions by a number of formulas. Four of the most satisfactory ones are given below:—

Formula No. 1		Formula No. 2	
Engine Oil	2 gal.	Engine Oil	1 gal.
Tap Water	1 gal.	Tap Water	1 gal.
Copper sulphate	¼ lb.	Copper Sulphate	½ lb.
or		or	
Ferrous Sulphate	¼ lb.	Ferrous Sulphate	½ lb.
Quick Lime	¼ lb.	Quick Lime	½ lb.

Formula No. 3		Formula No. 4	
Engine Oil	2 gal.	Engine Oil	2 gal.
Water	1 gal.	Water	1 gal.
Kayso	4 oz.	Saponin	4 oz.
		(or extract from ½ lb. soap bark.)	

To make the emulsions with Bordeaux or iron sulphate-lime mixture, add to the oil the required amount of the metal salt, dissolved in one-half the water required, and add the lime in suspension in the remainder of the water. Mix a little, then pump the mixture into another receptacle by means of a bucket pump. A Bordeaux nozzle adjusted to give a fine spray is desirable. To make emulsions by means of Kayso, suspend it in water, add it to the oil, and pump as before. The Kayso is best wetted by adding water slowly and stirring, until a paste or dough is formed, then diluting until the required amount of water is present. When saponin is used it is merely stirred up in the water, the oil added, and the mixture pumped back and forth.

Other methods or formulas in preparing the emulsions may give equally as good results. Considerable force must be used in the pumping. We generally pump the emulsion at least twice. If Bordeaux or iron sulphate-lime mixture is used as an emulsifying agent, it must be freshly made. Bordeaux is useless for the purpose after it has stood

for a short time. These stock emulsions can be made by means of a power sprayer. The ingredients are put in a half barrel or other container and the suction hose and a hose from the return line placed in the container. The mixture is then pumped from one receptacle to another until emulsified.

The emulsions made in the manner described above have larger oil globules than the oil-soap emulsions. Those made by means of the basic metal hydroxides have a tendency for a little oil to separate out after a time. This can be emulsified again by re-pumping. The emulsions so made do not separate spontaneously in the presence of hard water, lime-sulphur, or in containers contaminated with lime or lime-sulphur, as do the soap emulsions.

When diluted with water, the emulsions tend to rise to the top, but can be kept properly mixed by the degree of agitation obtained in a power sprayer. By emulsifying the oil with a relatively large amount of Bordeaux or iron sulphate-lime mixture, an emulsion can be made which is heavier than water, and which can be more easily kept stirred by the agitators. If the right proportions are used, an emulsion with a specific gravity of 1 can be made. Pickering[4] gives the formula for such an emulsion of solar distillate.

Pickering believed that, where the so-called insoluble emulsifiers were used, the oil globules were surrounded by minute solid particles of the emulsifier. Text books,[5 6 7] give other explanations of the action of emulsifying agents in general, but most of them mention that Pickering's emulsions are exceptions to the general rule.

Holmes[5] describes the ideal emulsifying agent as a solvated colloid giving a tough elastic film, gelatinous and swollen on the side of the continuous phase (water) and coagulated and slightly wetted on the side of the dispersed liquid (oil). The proteins, alkali soaps, and the other hydrated colloids which can act as emulsifying agents for engine oils, fulfil the requirements of this theory. Holmes evidently believes that the emulsions made with Bordeaux mixture differ from those having hydrated colloids as emulsifiers. Yet Duggar and Bonns[8] consider dried Bordeaux films to be capable of hydration. Colloidal metal hydroxides are able to hold in combination a large amount of water. Clay was one of Pickering's "solid emulsifiers," yet under some conditions, clays are highly hydrated. It may be that the basic sul-

[5]Holmes, N. H. Laboratory Manual of Colloid Chemistry. N. Y., 1922.
[6]Bancroft, W. D. Applied Colloid Chemistry, N. Y., 1921.
[7]Clayton, W. The theory of Emulsions and Emulsification. Philadelphia, 1923.
[8]Annals of Mo. Botanical Garden, 5: 153, 1918.

phates of iron and copper, when freshly prepared, act as hydrated colloids, and fulfill the requirements of a good emulsifying agent, as given by Holmes. Pickering obtained good emulsions with solid emulsifiers only when they were freshly prepared and in the medium in which they had been precipitated. He failed to get satisfactory emulsification with previously dried materials, even when they were very finely divided. In the light of the modern conception of the colloid condition as a state in which any substance may exist, it seems unnecessary to make an exception of Pickering's emulsions.

It has been stated[9] that oil-soap emulsions should not be used with Bordeaux, due to change of phase and liberation of free oil. We have seen no signs of such liberation of oil when the soap emulsions are added to freshly prepared Bordeaux. A ½-½-50 Bordeaux mixture has been widely used as a stabilizer when oil-soap emulsions are to be used with hard water. Other substances, such as starch, flour, glue, casein, and calcium caseinate, which are used to stabilize oil-soap emulsions in the presence of the calcium ion, can be used as emulsifying agents. It seems probable that the so-called stabilizing material forms a film around any unprotected oil particle present. These oil particles may be gotten into the presence of the hydrophile colloid chemically, by destruction of the soap film, or mechanically, by breaking up by means of a spray.

The reason why only freshly prepared Bordeaux mixture is efficient as an emulsifying agent is somewhat obscure. This property is probably dependant on the degree of dispersion of the basic copper sulphate. Coagulation goes on rapidly in Bordeaux, due to the presence of two flocculating agents, lime and gypsum. If Pickering's views are correct, it may be the increased size of the particles which prevents their acting as an emulsifying agent. If we assume that the Bordeaux acts as a solvated colloid, the decrease in hydration due to coagulation may prevent emulsification. A parallel to the latter hypothesis exists in the case of skim milk. Fresh skim milk makes good emulsions for a time, but clabbered skim milk, where the casein has coagulated and become less hydrated, is not a satisfactory emulsifying agent.

It is not within the scope of this paper to discuss the advisability of replacing lime-sulphur with engine oil emulsion as a scale spray. It may be said, however, that in the Middle West 2% engine oil emulsified according to the Government Formula, is considered to be an efficient

[9]Mahin, E. G. and Carr, R. H. Quantitative Agricultural Analysis, New York, 923.

scalecide. Comparisons have been made of emulsions made according to various methods, as to control of San Jose Scale and the grain aphis. The results are given in the following tables:—

TABLE I. EFFECT ON SAN JOSE SCALE OF 2% DIAMOND PARAFFIN OIL EMULSIFIED BY VARIOUS METHODS

Emulsifying Agent	*Number Counted*	*Percentage Killed*
Potash Fish oil Soap	815	96.2%
Kayso	1168	97.8%
Saponin	1043	98.5%
Bordeaux Mixture	1317	95.7%

TABLE II. EFFECT ON THE GRAIN APHIS OF 2% DIAMOND PARAFFIN OIL APPLIED IN THE DELAYED DORMANT STAGE. (UNDER LABORATORY CONDITIONS).

Emulsifying Agent	*Number Counted*	*Percentage Killed*
Potash Fish oil Soap	316	92.0%
Kayso	287	96.2%
Bordeaux Mixture	941	90.0%

These counts give evidence that the efficiency of the oil is little affected by the nature of the emulsifying agent. The emulsions of oil with Bordeaux, Kayso and saponin seem to have been as effective as emulsions made according to the government formula. The differences in the percentage of control are probably due to experimental error. The degree of control of aphis under field conditions varied with the time of the application and care used in spraying. In one case, 2% oil-Bordeaux emulsion was applied in a heavily infested orchard when the buds were just opening and the aphids were clustered on the green tips of the buds. Under these conditions 96% control was obtained. The results against the grain aphis suggest that the cold emulsions might be a valuable means of control of more serious aphis pests.

The emulsions made according to methods given above promise to be as valuable as the oil-soap emulsions, and are somewhat cheaper and easier to prepare. One hundred gallons of 2% oil emulsion cost from 34c to 48c depending upon the emulsifying agent used. Bordeaux and iron sulphate-lime emulsions are the cheapest. Not having any soap in their composition, they are compatible with Bordeaux, lime-sulphur and lead arsenate, and can be used with hard water.

A REFRIGERATOR FOR SHIPPING LIVE INSECTS[1]

By JOHN N. SUMMERS

The satisfactory shipping of imported parasites of the gipsy moth from the countries where they are obtained to the United States Bureau

[1]Mr. A. F. Burgess suggested the ice cream shipping tub as being best adapted to our needs.

of Entomology Laboratory at Melrose Highlands, Mass., has long been attended with considerable difficulty. With those species which can be obtained safely in the hibernating stage the problem is comparatively simple, but with others the summer broods have to be collected as either they use hibernating hosts which would be dangerous to import or they can only be obtained in satisfactory numbers during the summer. Some of these species may be handled best by collecting and shipping the parasitized gipsy moth larvae while with others we collect the cocoons or the puparia. To insure safe arrival the host larvae must be kept alive until the parasites issue and the parasite adults must be prevented from emerging en route. In either case refrigeration is necessary for without it the host larvae will only live for a short time and as the pupal stage of the summer broods of parasites is short, the adults will emerge and die long before they reach their destination.

The successful importation of parasites is therefore dependent upon proper refrigeration en route. This can be obtained for the trans-oceanic part of the route by having the boxes placed in the cold storage rooms of the vessels, but no such facilities are available on land. Our difficulty lay in getting suitable refrigeration for long overland shipping, particularly for the shipments of parasites which were sent from Japan. As speed was a vital factor, all such shipments were sent by express. Although the company handles considerable amounts of perishable produce it does not own any small refrigerators as all of these belong to the individual shippers. At times it is possible for the company to borrow one of these small refrigerators but it is not certain that one will be available when needed. Therefore we were compelled to secure some of our own to insure that they would be at hand to receive our shipments.

Information about the various types of small refrigerators in use was obtained. Of these, the type used in shipping ice cream appeared to be the best for our purposes. Its weight when iced was not excessive and as it is in general use express employees are familiar with it and would be almost certain to give one the proper attention. We had to avoid the danger of having the water from the melting ice penetrate to the parasites, which might result if the refrigerators were placed in any position but upright. With the ice cream shipping tubs there would be small danger of this owing to their shape and to the fact that they are familiar objects.

Refrigerators of a ten gallon capacity were obtained, these consisted of heavy metal cans eleven inches in diameter and twenty-four inches

high enclosed in heavy wooden tubs. These tubs were thirty inches high, nineteen inches in diameter at the bottom and twenty-one inches

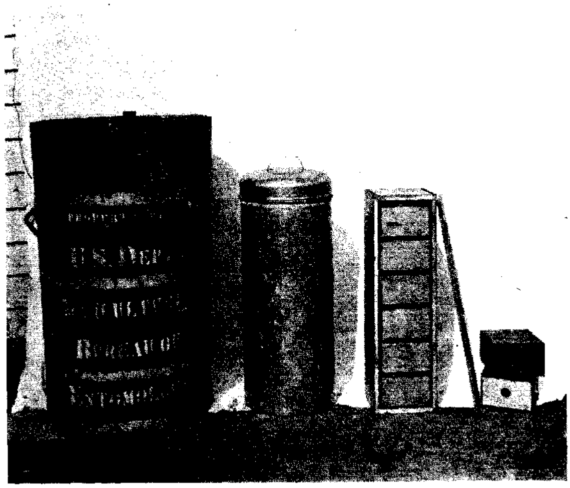

Fig. 6—Component Parts of Refrigerator and Shipping Box (Photo by Hood)

in diameter at the top. The tubs did not possess covers so they were fitted to heavy wooden ones which were padded around the edge to make them as tight as possible and prevent the rapid melting of the ice and the escape of the cold air. To the center of each cover on the inside a small padded wooden block was attached which pressed down on the handle of the can cover to keep the latter securely in place. To prevent the can being thrown around inside and insure an even layer of ice around it, it was held centered at the bottom by three or four small wooden blocks and at the top by a pair of iron straps which were attached to the tub at the sides and were tightened around the can by means of two bolts.

When the tubs were purchased there were vents in them which would allow the water to drain off. These were plugged so that the water would remain until the refrigerators were re-iced, as it would remain cold for some time and prevent the warming up of the contents.

The boxes in which the parasites were to be shipped were of the same type which has been found to be so satisfactory for this purpose, i. e.

a number of light wooden ones enclosed in a heavier wooden box and, of a size to fit the metal containers of the refrigerators. The large boxes were constructed of half inch stock and measured 7½ x 7½ x 22¾ inches. Each one of these was fitted with six small boxes measuring 3½ x 6½ x 6½ inches, constructed of quarter inch stock. For convenience in removing the parasites and to guard against the escape of any, which might occur if it was necessary to remove the covers of these small boxes, an inch hole was bored in one side of each one. This hole was covered by tacking over it a square of tin which could be removed for the insertion of a glass tube when the shipment arrived.

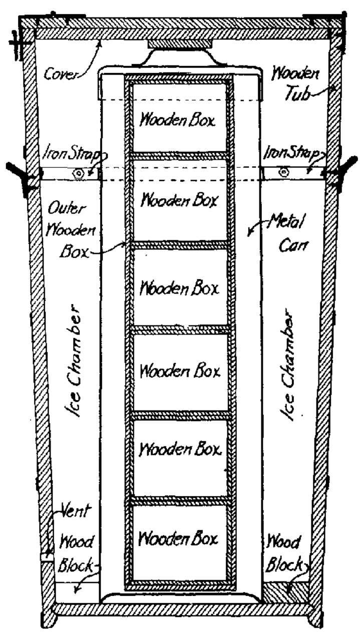

Fig. 7—Diagram of Refrigerator and Shipping Box Assembled (By Guild)

The refrigerators received a very good testing the past summer from a shipment of *Apanteles fulvipes* from Japan. This species is a difficult one to ship over a long distance as its cocoon stage is only about six days, which makes proper refrigeration absolutely necessary. Boxes for shipment were constructed in Japan. Two of these were packed with

parasitized gipsy moth larvae when the first *Apanteles* larvae were beginning to issue, and shipped from Yokohama on May 19, in the cold storage room of one of the fast Trans-Pacific vessels. The boxes arrived at Seattle May 29 and were placed immediately in two of our refrigerators which were on the dock all iced ready to receive them. As the refrigerators were cold there was no opportunity for the parasites to suffer from a rise in temperature. The two refrigerators were immediately started for Melrose Highlands and were re-iced once en route. The shipment arrived at our Laboratory June 5, having taken eighteen days from Japan. On arrival the shipment was unpacked immediately. All of the ice had melted but the water was very cold. About five per cent of the host larvae were alive and active. The parasite larvae had issued from their hosts and spun their cocoons but none of the adults had emerged. *Apanteles* adults began to emerge shortly after arrival and continued for several days, every cocoon producing a vigorous adult.

The refrigerators were also tested for the shipment of live larvae. A collection of web worm larvae, *Hyphantria* sp., was made at Seattle, packed in one set of boxes and shipped August 11, to Melrose Highlands in one of the refrigerators, taking seven days to reach there, being re-iced once en route. The shipment was in good condition on arrival with about half of the larvae alive and vigorous. Results were very good considering the fact that it was not possible, owing to limited facilities, to exercise quite the care in packing necessary to get the best results.

Much of the success of such shipments depends upon the care used in packing. When parasitized larvae are sent too many must not be placed in each box; with the gipsy moth we pack from fifty to a hundred, depending upon their size, and plenty of small branches of foliage must be included. The foliage serves two purposes,—it provides food for the larvae, and prevents them from being thrown against the sides of the box and injured. If parasite cocoons or puparia are sent it is usually best to pack these in layers separated by sheets of paper but some experimenting may be necessary to determine the best way.

The small boxes should be lined with blotting paper to absorb the moisture precipitated when the temperature is lowered otherwise there will be an excess of moisture and the growth of mold.

The illustrations were made by Messrs. C. E. Hood and I. T. Guild of the Gipsy Moth Parasite Laboratory, and the method of holding the can in place devised by Mr. H. I. Winchester.

THE PINK BOLLWORM OF THURBERIA, *THURBERIPHAGA CATALINA*

By J. L. WEBB, *Entomologist, Southern Field Crop Insect Investigations, Bureau of Entomology, Department of Agriculture*

ABSTRACT

The pink boll worm of *Thurberia* constitutes a great menace to the cotton grown in the valleys of Arizona below the range of *Thurberia*. An account of the rearing of the adult is given, including notes on parasites of the larval stage. A list of other *Thurberia* insects collected by C. H. T. Townsend is also included.

During the summer of 1913, Dr. W. D. Pierce and Dr. A. W. Morrill made an investigation of the insects associated with the Thurberia plant in several localities in Arizona. In their published report[1] they make mention of "the Thurberia Boll Worm" and give brief descriptions of all stages except the adult which was at that time unknown.

In December of the same year, E. A. Schwarz and H. S. Barber investigated the status of the Thurberia plant and the newly discovered Thurberia boll weevil, *Anthonomus grandis thurberiae* in the mountains of southern Arizona.

Besides the weevil they found abundant evidence of the infestation of Thurberia bolls by a species of bollworm which they called the "pink bollworm." Both these men expressed the view that the pink boll worm (of Thurberia) constituted a greater menace to the cotton grown in the valleys below the range of Thurberia than did the Thurberia boll weevil.

In August 1918 Dr. C. H. T. Townsend was sent by the Bureau of Entomology to the Santa Catalina mountains near Tucson, Arizona, for the purpose of rearing the adult form. His report follows:

"Permanent camp was made August 14, 1918, in the upper end of Sabino Basin, Altitude 3,550 ft. This camp was well situated for the work, being surrounded by Thurberia not only close by but also in all directions at both higher and lower levels. The plant was noted from 3,000 ft. up to 4,800 ft. in Sabino Canyon and around the sides of the Sabino Basin. Above 4,800 ft. it was not found anywhere, the pinyon beginning at that level. The altitudes were taken by aneroid.

PINK BOLLWORM OF THURBERIA.

Four hundred forty infested bolls were collected from August 28 to October 4, the bulk of these being found during the last two weeks of September. Not counting a number of worms that escaped from time to time from the rearing receptacles, 142 bollworms were secured from these bolls.

Twenty-two of these worms transformed to pupae in the earth. These were taken with great care from the earth October 13 and packed in cotton in vials for transportation to Washington.

The 142 bollworms yielded 41 hymenopterous parasites, belonging to at least 3 species as follows:

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[1]Washington Ent. Soc. Vol. xvi, pp. 14–23.

Apanteles[2] n. sp	32
Microbracon n. sp	7
Perisierola n. sp	1
Microhymenopter undet	1
Total hymenopt. parasitism	41

The above is a parasitism of nearly 29%.

In addition to this parasitism, which may yet be increased by muscoid parasites issuing later from the pupae, from 5% to 10% of the infested bolls containing worms are opened by the Southwestern jay, *Aphelocoma* sp., probably the form known as *Sieberi arizonae* Ridgway.

Thus some 35% of the worms appear to be destroyed by natural enemies in the Sabino Basin region, at the least estimate, or well over one-third.

The 22 pupae will, I hope, yield the adult this season, so that the species may be identified. A single specimen of a moth found in one of the insectaries, which had crawled in during the night and may have been attracted by the odor from the Thurberia bolls, was determined by Dr. Dyar as *Perigea continens* Edw. It is a noctuid and about the right size for the Thurberia bollworm moth, but may have nothing to do with it.

The worms in the bolls were extensively attacked, both dead and alive, by two or more species of Phorids while in the insectaries. These phorids are attracted to all fermenting substances, and the frass from many worms assembled in small space is probably the cause of their appearance in great numbers in the rearing receptacles. They accounted for the large mortality in the worms. If the receptacles were covered tightly enough to exclude them, the air was also excluded. As they were not met with in the bolls in the open, they are not taken into account as a control factor.

OTHER THURBERIA INSECTS

Anthonomus thurberiae Pierce—Found frequently in all stages.

Dichomeris deflecta Busck—Many evidences found during August.

Inglisia malvacearum Ckll.—This scale was found in abundance on two plants at 3,550 and 3,800 ft.

Cecid leaf-gall—Very abundant about the first of September.

Thyanta perditor Fab.—Adult found sucking green boll at 4,100 ft.

Sphyrocoris 2 n. spp.—Nymphs found sucking green bolls at 3,800–4000 ft.

Formica fusca guava Buckley—A perfectly constant attendant on the Thurberia plants everywhere. No plants found without them. I did not see the species elsewhere.

Eriophyes sp.—Bad infestation of plants in patches at 3,500–4,000 ft.

Acridiid sp.—Greenish-yellow nymphs found on Thurberia on half dozen occasions at about 3,500 ft. Not seen elsewhere.

Many bees and *Acmaeodera* sp. were collected in the flowers; *Cardochilis* n. sp., *Cryptocephalus* sp., on the foliage; Gen. Nov. aff. *Stenophasmus* sp. on an infested boll, and *Lygaeus belfragei* Stal on boll.

The hymenoptera were det. by Gahan and Rohwer; coccid by Morrison; heteroptera by Gibson; ant by Mann.

C. H. T. TOWNSEND."

Upon arrival in Washington the 22 pupae of the bollworm mentioned

[2]This species has been described as *Apanteles thurberiae* Muesebeck, in Proc. U. S. Nat. Mus. Vol. 58, pp. 507–508.

in Townsend's report were divided into two lots of 11 each. One lot was sent to T. C. Barber at Brownsville, Texas, and the other to J. D. Mitchell at Victoria, Texas.

Mr. Mitchell's rearing records are as follows:

Oct. 29, 1918,—pupae received at Victoria, Texas.
Aug. 2 to 8, 1919,—3 moths emerged.
Aug. 27, 1919—1 moth emerged.

The following are Mr. Barber's records:

Aug. 6, 1919,—	1	moth	emerged.
Aug. 23, "	1	"	"
Aug. 26, "	1	"	"
Aug. 29, "	1	"	"
Sept 1, "	1	"	"
Aug. 28, 1920,—	1	"	"

It will be noted from Mr. Barber's records that one individual remained in the pupa stage for practically two years.

Specimens submitted to Dr. Harrison G. Dyar were determined by him as representing a new genus and species of the family Noctuidae, Acronyctinae. He described it as "*Thurberiphaga catalina*.[3]

NOTES ON THE BIOLOGY OF *DESMOCERUS PALLIATUS*

By GLENN W. HERRICK, *Ithaca, N. Y.*

ABSTRACT

The cloaked knotty-horn beetle (*Desmocerus palliatus*) lives on the common wild elder and attacks the Golden elder which is used for ornamental purposes. The eggs have been found attached to leaves of the elder but it is questionable if this is normal. The larvae bore into the stems of the elder, just above and below the surface of the soil. The larvae pupate in the spring in their burrows in the stems and the adults appear during the last of May or early June. The beetles feed sparingly on the leaves before ovipositing.

This beetle, commonly known as the cloaked knotty-horn, is a native species and evidently widely distributed in the United States and it occurs in Canada. It has been recorded from Ontario, Canada, and in the United States from Massachusetts, Connecticut, New York, Pennsylvania, and New Jersey southward to Virginia, North Carolina, and Louisiana and westward to Indiana and Kansas, at least. Its original food plant is apparently the native elder (*Sambucus canadensis*) on which the beetles are often found in considerable abundance. For example, Mr. Morris in one of his delightful accounts of a collecting excursion, says, "in the little glade, among the thickets of elder, I captured seven specimens of this beautiful beetle in about an hour—always on the underside of the foliage or crawling on the stems****.

[3]Insecutor Inscitiæ Menstruus. Vol. VII, p. 188.

That season I took over seventy between June 20 and July 25, nearly always on early elder growing in woodland glades and generally on the foliage." The writer has taken the beetles at Ithaca on both the golden elder and the common wild elder. I have also collected it on the wild elder at Deposit, N. Y.

The beetle has been present here at Ithaca for some years on the golden elder used in lawn plantings. The larvae have proved to be seriously injurious to this very useful and beautiful shrub, greatly marring its symmetry and beauty by reason of the dead and dying branches that occur here and there throughout the growth.

The larvae work at the bases of the stems partly above ground but mostly below the soil. Their burrows run nearly parallel with the long axis of the stem and are usually packed full of castings. From six to eight inches above the soil the stems are full of the exit holes of the beetles while the interior is often riddled with burrows of the larvae.

The larva is creamy-white and when full-grown and extended is fully an inch in length and some specimens exceed an inch. The head is brown and the mandibles black in color. The prothorax is wide and flattened and each of the first seven abdominal segments bears a flattened area on the dorsal side reminding one of the much more prominent callosities on the dorsal sides of the segment of the larva of *Mallodon melanopus*. The pupa is slightly more than three-fourths of an inch in length and its appearance is well shown in plate 7.

The adults begin to appear here at Ithaca in June. My notes record one adult on June 14 and another on June 18. On June 13 I found three adults that had transformed in the larval burrows in the stems below ground but had not yet emerged. In the cages to which larvae were transferred on March 30, adults emerged (4 of them) as early as May 30 (1910). It is probable that the transformations of these specimens were accelerated somewhat by the unnatural conditions in which the larvae found themselves and perhaps the temperature was somewhat higher in the cages than in the portions of the elder below ground.

The beetles feed to some extent on the foliage of the elder, eating inward from the edges and producing notches in the leaves. One female was present on the plant and her activities followed for a little more than a week. The male was present on the 23rd of June and the two were in copulation at this time.

On June 14 I found what I supposed were the eggs deposited by another female present on the foliage. I had expected to find the eggs white in color and supposed they would be deposited on the bark near the bases

of the stems. The bodies which I took to be the eggs were deposited on the leaves on their sides and were fusiform in shape, of a clay-yellow color and the surface of each one was longitudinally wrinkled. They are well shown in plate 7. On June 16, 1921 I took several of the beetles on the common wild elder at Deposit, N. Y. These beetles were confined in tumblers with leaves of the elder for a day or two until time could be found to care for them. During the night of the 18th the beetles deposited several of the fusiform, clay-yellow wrinkled eggs in the tumblers identical in shape, size and appearance with those found on the leaves to which reference has already been made. On the 19th four more eggs were laid by one of the beetles. I did not, however, succeed in getting any of them to hatch. The eggs are about 3 mm. long and 1 mm. in diameter.

It is quite possible that the larvae may be destroyed by the use of paradichlorobenzene, applying it in the same manner as it is applied to control the peach-tree borer. I am inclined to think, however, that the gas might be more effective if the crystals were applied in the spring during the latter half of April rather than in the fall.

RED BUG CONTROL IN SOUTHERN PENNSYLVANIA

By J. R. Stear, *Assistant Entomologist, Penna. Bureau Plant Industry, Harrisburg, Pa.*

Abstract

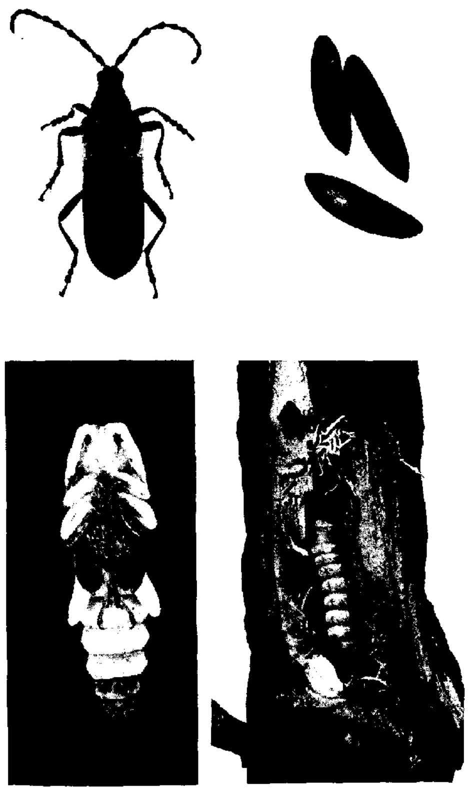
The hatching period of the bright red bug, *Lygidea mendax*, in southern Pennsylvania comes so late in the blossom pink stage of nearly all varieties of apples that the pink spray is ineffective in control. A comparison of pink with the petal fall spray on the York Imperial, a late blooming variety, gave little difference in control. Two applications of nicotine gave no additional control. On earlier blooming varieties the petal fall spray would prove much more effective. One application of nicotine at petal fall is advised.

The species of red bug considered in this article is known as the false or bright red bug.[1] In southern Pennsylvania it is the species responsible, so far as observed for all injury to apples. The dark red bug,[2] thus far has not been collected or reared from apples at the Chambersburg laboratory.

The usual recommendation for red bug control, calling for a nicotine spray before the blossoms open has been followed in southern Pennsylvania with varying results. Considering this, it appeared desirable to correlate the hatching of the red bug nymphs with the blossoming of several varieties of apples.

In 1921 and 1922, the writer correlated the first hatching of red bugs with the blooming period of several apple varieties, viz., York Imperial,

[1] *Lygidea mendax* Reut. [2] *Heterocordylus malinus* Reut.



Desmocerus palliatus; Adult, Eggs, Pupa, and Larva in burrow.

Grimes Golden, Stayman Winesap and Jonathan. In 1921 the first nymphs were observed on April 7th, as many as six nymphs being found on a single blossom bud cluster. On this date all four varieties were in condition for spraying in the pink. By April 9th, however, all were partly in bloom except the York Imperial which did not bloom until April 14th. In 1922 the first nymphs were observed on April 23rd. At this time all varieties were in the pink stage, but by April 26th all were in bloom except the York Imperial which did not bloom until May 1st.

From this it appeared that except in the case of the late blossoming York Imperial, hatching occurred so late in the pink stage that the pink spray could not be delayed long enough to catch the nymphs. Even if it were possible to delay the pink spray until a couple of days before the blossoming period, not more than 50 to 75% of the nymphs would be exposed to the spray. In 1923 hatching occurred over a period of 6 days. Twenty-five percent of the nymphs hatched in the last four days of this period, during which time the trees were in bloom.

Frost[3] has shown that the hatching period of *L. mendax* occurs too late for the pink spray to catch many of the nymphs, and recommended that in red bug control nicotine be applied at petal fall and two weeks later rather than in the pink spray.

In order to compare the effectiveness of later sprays with the pink spray, and also to determine whether sufficient additional control is secured to justify two applications of nicotine, experimental spraying was carried on in an infested York Imperial orchard in 1922.

The orchard was divided into four plots which were treated as follows: Plot 1 sprayed in the pink. Plot II sprayed in the pink and at petal fall. Plot III sprayed at petal fall. Plot IV sprayed at petal fall and 2½ weeks later. Check trees were left in Plot I. The trees were twelve years old and 3-3½ gallons of spray were used per tree. Nicotine sulfate was used at the rate of ¾ pint to 100 gallons of dilute lime-sulfur. The pink spray was applied on April 26th, three days after nymphs were first observed. Petal fall spray was applied on May 8th, and the third spray on May 26th.

[3]Jour. of Ec. Ent., Feb., 1922

Comparative Results of Red Bug Sprays

Plot	Treatment	Tree No.	Total Apples	Red Bug Apples	Per cent Red Bug
I	Pink Spray	1 2 3	491 1504 576	14 33 4	2.8 2.1 .69
II	Pink and Petal Fall	1 2 3	795 354 373	8 9 6	1. 2.5 1.6
III	Petal Fall Spray	1 2 3	126 1213 480	0 26 4	.0 2.2 .83
IV	Petal Fall & Two & half wks. spray	1 2	138 275	1 4	.7 1.45
	Checks	1 2	49 838	7 110	14.3 13.1

In averaging up these results we get the following percentages: Pink spray 1.9% Red bug. Pink and petal fall 1.5%. Petal fall 1.64%. Petal fall and 2½ weeks later 1.2%. These percentages are so small and so close together that there is no practical difference in favor of any of the spray treatments. On the basis of these results and assuming careful spraying, we would conclude that a single application of nicotine at petal fall will give excellent control without an additional spray.

It is unfortunate that the experiment could not have included an earlier blooming and susceptible variety such as Grimes Golden. With such a variety the difference in favor of the petal fall over the pink spray should be very marked.

HABROBRACON JUGLANDIS ASHMEAD AS A PARASITE OF *PLODIA INTERPUNCTELLA* HUBN.

By E. R. deOng, *University of California*

The Indian Meal Moth, *Plodia interpunctella* Hubn., in California is commonly attacked by the parasite *Habrobracon juglandis* Ashmead. Parker mentions it under the name of *Habrobracon hebetor* Say as frequently attacking this larva "but not appreciably affecting the infestation in California," (U. S. Dept. Bul. 235, 1915). This parasite was found to be the most abundant and widely distributed of any attacking *Plodia*, in a study of insects of stored products made in 1918 for the State Food Administrator. It was also found to breed upon a caterpillar recently introduced upon peanuts, *Aphomia gularis* Zeller.

The life history data were from insects in close confinement and

without the best equipment for such type of work. The temperature range was from 24° to 30° C. (75° to 86° F.) to simulate natural conditions in the ordinary warehouse of interior California during the summer.

LIFE HISTORY DATA OF *Habrobracon juglandis*

No.	Number of Specimens	Length of egg stage	Length of larval stage	Length of pupal stage	Period from egg to adult
		Days	Days	Days	Days
1	7	2	6	6 to 8	14 to 16
2	2	—	—	7 to 8	—
3	7	2	5 to 7	6 to 7	15 to 16
4	5	3 to 4	4 to 5	10 to 11	18 to 20
5	5	3	4 to 5	—	—
6	8	2	5	—	—
7	6	2 to 3	4	10	16 to 17
8	4	3	5	—	—
9	1	3	4	5	12
10	6	2 to 3	7	—	—
11	3	2	5 to 8	—	—
Average		2.6	5.2	7.4	16

The average development period of *Plodia interpunctella* under California conditions is given by Parker (former citation) at fifty-three days. Comparing this with the average period of sixteen days from egg to adult of the parasite, it will be seen that there is a possibility of three and a partial fourth generation to one of the host.

Oviposition Habits. The caterpillars frequently recognize the parasite as a possible enemy and may attempt to escape from it. After being stung, however, paralysis occurs in twenty to twenty-five minutes and then from one to three pearly white eggs are attached to the caterpillar. Three parasites were occasionally reared from one mature caterpillar, but in one instance when five eggs were deposited on a single host four larvae matured but only one adult emerged. Many caterpillars that were confined with parasites were stung and paralyzed even though no eggs were deposited upon them. In one instance eleven *Plodia* larvae and one female parasite were confined in a vial and within two hours all the caterpillars had been paralyzed. Some of these were kept for three weeks and at the end of this time they had shriveled up and turned black, but the exact time of death could not be determined.

Oviposition began in one or two days after the adults emerged and continued over a period of from seven to nine days. The total number of eggs recorded from a single parasite ranged from fifteen to twenty-four.

Scientific Notes

Note on the Cotton Boll Weevil in Kansas. On Oct. 10th and 11th I found quite a number of adults and larvae in bolls on cotton in southern Kansas, Montgomery County. This county lies immediately north of Oklahoma, and according to the best information I can get there is considerable cotton growing immediately south of this county.

Specimens of this insect have been submitted to Mr. J. L. Webb of the Bureau of Entomology, who states that they are typical cotton boll weevil.

E. G. Kelly,
Extension Entomologist.

A Mealy Bug on Grape. Grape growers in the vicinity of Lawton and Paw Paw, Michigan, during the summer of 1923, complained of injury to their grapes, caused by a mealy bug. The infected clusters were not only rendered unsightly by the presence of honey dew but the grapes showed a tendency to drop before they were ripe. This left the cluster ragged in appearance and exposed the white cottony egg masses along the stems. The mealy bug proved to be the omniverous species ***Pseudococcus maritimus*** Ehr., which is known to occur on a number of different hosts.

Eugenia McDaniel,
Research Assistant in Entomology

The Effect of Low Temperatures on the San Jose Scale in Georgia. In taking records on the results of lubricating oil emulsions and other sprays for the control of the San Jose scale, *Aspidiotus perniciosus* Comstock, on peach trees in Georgia, notes were also made on the mortality of the insect from low temperatures. The table below gives in terms of percentages the dead scale insects found on the check or untreated trees of the experiment before and after the cold period.

Date (1923)	Treatment for scale	Minimum temperature	Percent scale dead
Feb. 9	No treatment	36° F	12%
" 16	" "	26° F	27%
" 19	" "	21° F	38%

The above table shows that as a result of the low temperatures there was an increased scale mortality of 26 % on the trees that had received no treatment whatever during the winter for the control of the insect. The minimum temperatures recorded for a four day period were as follows: Feb. 16, 26° F; Feb. 17, 23° F; Feb. 18, 18° F; and Feb. 19, 21° F. These temperatures were unusually low for Central Georgia, and some large female scales and *all crawlers* were killed during the period.

On March 20th, 1923, a minimum temperature of 23° F was recorded in Central Georgia which killed about 20% of the peach blooms, but did not affect the scale mortality to any extent. The minimum on the day before this freeze was 51° F and on the day after 35° F. The low temperature during the second cold period of 1923 in Georgia was perhaps of a too short duration to kill the San Jose scale.

Oliver I. Snapp and C. H. Alden, *U. S. Bureau of Entomology, Fort Valley, Georgia*

Unusual Damage to the Floors of a House by a Species of Pemphredinid Wasp, Stigmus fulvicornis Rohwer. During the latter part of August 1923 the writer was requested to visit the home of Mr. Ed. Williams in Starkville, Miss. and investigate the damage to his floors caused by what he thought to be ants. After reaching Mr. Williams' home the writer was very much surprised to find a portion of the floor of his porch bearing numerous holes about the diameter of the head of an ordinary pin or slightly smaller. By the side of a number of these holes were small piles of sawdust. Flying in the air above these holes and crawling on the floor here and there were numerous small wasps which on superficial examination might have been taken to be parasites of whatever insect was damaging the floors. The holes in the floor bore a striking resemblance to those of Ipid beetles, in fact the writer would, upon a hasty examination, have concluded that a species of Ipid was the depredator and that the wasps were parasites on them. A very careful examination of several nests proved that the wasps were the cause of the damage and that they were using the floor as a place in which to construct their nests. A number of the insects were secured but they were so immature that no effort was made to have them determined.

With the literature available the writer was able to place the wasp in the genus *Stigmus*. Specimens were forwarded to Mr. S. A. Rohwer, of The United States National Museum, with a request for a specific determination. Mr. Rohwer wrote that the species was nearest *S. conestogorum* Rohwer, but differed from this species in a number of ways, enough to warrant him in calling it a new species, to which he gave the name *fulvicornis* because of its yellowish or ferruginous colored antennae. Mr. Rohwer took issue with the writer in regard to the wasp's ability to construct nests in the floor. He was of the opinion that the wasps were using the holes made by Ipid beetles or else nail holes for their nests. There is no doubt about the wasps constructing holes in the floor as Mr. Williams observed them carrying sawdust-like frass out of their holes. The writer also examined enough of the nests to be convinced that the wasps were solely responsible for the nests and not the wood-boring beetles, as one would ordinarily think.

A review of the literature dealing with the habits of the wasps of the genus *Stigmus* contains no reference to any species of the genus ever having attacked furniture or floors; normally the wasps breed in the stems of plants or twigs of trees but there is a reference to one species having been bred from a gall. It is left for one to speculate as to why this species should attack floors when there were plenty of trees and plants nearby in which it might have constructed its nests. Will this species continue to be a household pest or was this simply a variation in the habit of the wasp?

On September 10th, a further visit was made to the home of Mr. Williams where the writer's attention was called to the holes made in the floor of the dining room and hall. The floor was hard and well preserved, and not soft and punky like that of the piazza. Both floors were of pine but that of the piazza had been subject to weathering, while that of the interior of the house was almost as well preserved as it was when the house was built. After seeing the nests in this type of wood one was more than ever convinced of the wasp's ability to construct nests in other kinds of wood besides soft and decaying lumber. As a rule the nests in the interior of the house were constructed in the soft wood between the hard grain layers but this was not invariable, for a number of nests were observed which penetrated even the hard grain layers. On the porch a count of the nests occurring in one plank was made and it was found that fifty nests occupied this plank, which was about three

inches wide and four and a half feet long. The distribution of the holes in the plank was not uniform but the holes were rather scattered; in some places there were as many as six holes to the square inch, whereas in other places there were only one or two, or perhaps none, in an area equally as large.

One hole, which was examined, extended into the floor vertically for a distance of one-fourth inch when it suddenly turned at right angles and ran parallel with the surface of the floor for seven inches. In this gallery was found a great deal of frass, but no signs of the wasp or its immature stages.

The writer recommended that Mr. Williams treat each of the holes with carbon bisulphide by injecting this material into the holes with a little oil-can or syringe. This treatment to be followed in a couple of days by painting or varnishing the floor.

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The Aldrich Collection of Diptera. The National Museum has recently received as a gift from Dr. J. M. Aldrich his private collection of Diptera. This collection was begun in 1890, and for 28 years received a good share of the owner's efforts; since he went to the National Museum in 1918 it has, however, received no additions. A recent inventory showed it to contain 44,610 pinned specimens and 4,145 species fully named; 534 of the latter were represented by type material. There are some hundreds of undescribed species; and as Dr. Aldrich collected for many years in the Pacific Coast and Rocky Mountain regions, his collection contains many named species not heretofore represented in the National collection.

Dr. Aldrich also donated to the museum his card index of the literature of North American Diptera, begun in 1898 and now extending to about 70,000 references as nearly as can be estimated. With the exception of about 20 hours' work, this is all by the hand of the owner himself, and represents to a large extent his own conclusions from the literature rather than a mere compilation.

In a letter to his chief presenting the collection and index, Dr. Aldrich states that he was deterred from taking this action sooner because the salaries paid by the museum are still on the scale established in 1882 (except for a temporary war bonus of $240), and he did not feel sure that he could continue permanently as one of the curators. Recently, however, under the reclassification act passed by the last congress, the museum staff have been assured of a new pay schedule approximating the requirements of the present time. Science, *October 19, 1923*